A. I should say it was about 15 feet in diameter.

3178 Q. Where is that?

A. Well, there are two or three of them I can recall particularly the Green Avenue relief sewer.

Q. That is in Brooklyn?

A. That is in Brooklyn.

Q. And another one?

A. The outlet sewer for the Flatbush and Fort Hamilton Districts, which discharges into New York Bay at the foot of 65th Street.

Q. Any other, that is in Brooklyn I suppose?

A. These are all Brooklyn, all the large sewers.

Q. Any other?

A. There was a large sewer that was done under my supervisory charge in Queens at the foot of Webster Avenue, not quite as large but approximately.

Q. How many inhabitants does the Green Avenue sewer serve?

A. That is more especially a storm relief sewer. It is not supposed to take concentrated domestic sewage. As a matter of fact it does take it, but it was not intended to.

Q. The other, the Hamilton Avenue one?

A. The 65th Street sewer, which I think was the next one mentioned is built for a very large population.

Q. How large?

A. Well, the territory is 5,000 acres approximately, and I suppose there will be eventually 50 people to the acre. That would be 250,000 people, but it will be a long time.

Q. How many people are there now?

A. It would be difficult for me to say, without referring to statistics. I should judge about 50,000 people.

Q. These sewers discharge at low tide?

A. Just below low tide.

Q. How much below?

A. Probably about 4 feet.

Q. When were they built?

A. The 65th Street sewer was built, as I recall it, was completed about 1901.

3179 Q. The Green Avenue sewer when was that built?

A. The Green Avenue sewer was completed about 1894.

Q. How near the shore line do these sewers discharge?

A. The 65th Street sewer was carried out on a pier, a concrete pier to the pierhead line.

Q. The Green Avenue sewer?

A. The Green Avenue sewer discharged at the head of Gowanus Canal. That sewer has been diverted now and discharges into the East River at about the foot of Raymond Street.

Q. At any depth?

A. I am not familiar with that within the last two or three years.

Q. From the dilution standpoint, could the sewers be discharged much worse than they are?

A. No. The concentrated outlets are very much more objection-

able than a small number of outlets carrying the same amount of sewage, but discharged at a large number of places.

Q. What is the character of the sewage discharged into Boston Harbor; is it storm water, combined sewage?

A. Mostly domestic sewage with some manufacturing wastes. The outfall sewers are not supposed to take any large amount of rain water, for the reason it is almost always pumped and overflows into the various streams that they cross within the city limits, which relieves the city sewers from the storm water before the sewage is delivered at the pumping station at Moon Island.

Q. So that the sewage as it is discharged into Boston Harbor is pretty well concentrated sewage?

A. Typical domestic sewage from a large city.

Q. And that is about as objectionable as you can conceive of, is it not?

A. There is not much difference in sewage from that standpoint.

Q. Is not sewage diluted with storm water less objectionable than that which is not?

A. Oh, yes, if you refer to that point.

3180 Q. Well, do you know whether or not the proposed Passaic Valley sewer is to serve storm water or not?

A. I believe it is to take a certain amount of storm water for a certain period of time.

Q. Well, is it not designed to take all the storm water of the City of Newark?

A. No, I do not so understand it.

Q. Where do you get your information from?

A. My understanding is that the capacity of the Passaic Valley sewer is limited to the amount of domestic wastes which will be discharged from the district by a certain time, 1940 or 1950, and that period to that time it is estimated there will be a surplus capacity which may be used so far as it will go to take care of certain storm water from the City of Newark, thereby giving the City of Newark an opportunity to build water outlets to take care of the combined sewers which they now have.

Q. You know the whole system at Newark at present is combined, do you not?

A. I believe it is, yes.

Q. And it is hoped to put this trunk sewer in operation at the expiration of three or four years?

A. That is my impression of the proposal.

Q. Now the Moon Island outlet I think is near the surface?

A. Right near the surface.

Q. Horizontal or vertical?

A. Horizontal.

Q. The Deer Island outlet, how much below the surface is that?

A. It is about 9 or 10 feet below the surface, was at the time I was there.

Q. What is the character, horizontal or vertical?

A. I was told it was horizontal. I did not see it.

Q. Who told you it was horizontal?

A. The engineer who was there, the engineer at the pumping station, I forget his name.

Q. You did not investigate?

A. I could not get down there, no.

3181 Q. You know as a matter of fact that it is a vertical discharge?

A. Do I know, no,—I understand it is horizontal. It may have a bend at the end of it, but I could not ascertain that. I do not think that it is of any importance.

Q. You don't?

A. No.

Q. Therefore you did not investigate it with any degree of care?

A. No, I did not.

Q. You do not consider it of any importance?

A. No, I do not.

Q. And the Nut Island outlets, what are they, horizontal or vertical?

A. I was told by Mr. Smith, the engineer in charge of that station that the outlets there at present are up vertically at the ends.

Q. What is the name of the gentleman who gave you this information?

A. His name is Smith, Frederick D. Smith.

Q. Would it surprise you to find that as a matter of fact the Nut Island discharge is horizontal and that the Deer Island is vertical?

A. Would it?

Q. Yes.

A. I do not know as it would surprise me very much. I do not consider it is essential to the success of the plan one way or the other.

Q. Have you got any memoranda taken at the time which show what Mr. Smith did tell you?

A. Yes, and I have the note here with me.

Q. Did you happen to see Mr. William H. Brown in your visit to Boston on that occasion?

A. Yes, I called on Mr. Brown.

Q. Did he go with you?

A. No, he did not go with me.

Q. How did you happen to reach the conclusion that you would need a guide to the Nut Island outlet?

A. For the reason that the outlet sewers are very deep

3182 there, and are more than a mile from the shore and the engineer, the captain of the steamer said that he—I think he said that he had never been in that part of the harbor, it was off the beaten track of the steamers and that was why I thought it would be necessary to have somebody in charge of the operation of the plant to go with me.

Q. Don't you know that a party from the New York Metropolitan Sewerage Commission attempted to find the Nut Island outlet and were unsuccessful?

A. I never heard that.

Q. Do you not know that Mr. Brown went with them and attempted to point it out and was not able to?

A. I never heard that.

Q. And they had to return and get a chart with a man who could indicate from actual observations, astromomical observations where the outlet was?

A. I never heard that.

Q. Would you be surprised to hear that?

A. Yes.

Q. That was not the reason why you took a guide?

A. No, I never heard of that.

Q. Well, what is the population as you understand it, that is served by the Nut Island outlet?

A. About 350,000 people.

Q. Now, just what did you observe at the outlet at Nut Island?

A. I observed two boiling streams as near as I can express it, of discolored water appearing at the surface. The tide at that time was almost slack water and the sleek which accompanied this boiling stream spread out in relatively small areas around the two outlet pipes. As I stated before the amount of sleek and the amount of odor was not as great as I had observed previously at Deer Island, but still it was very noticeable, and if I had seen it before I saw the Deer Island plant, it might have impressed me more.

3183 Q. How much in area did it cover?

A. I should say that the area covered at each outlet was in the neighborhood of 10 acres.

Q. When *did* you say it is covered, what do you mean by that?

A. I mean that the discolored area which was plainly noticeable from the upper deck of this boat covered about 10 acres. If I could have gone up higher it might have been bigger.

Q. How did you actually locate these 10 acres?

A. You mean estimate the size?

Q. How did you locate them?

A. They were in the vicinity of this boiling mass of water which I spoke of coming up above the outfall.

Q. How much below the surface is the outfall?

A. 30 feet below high tide.

Q. You saw a boiling stream?

A. Yes, it was a boiling mass.

Q. Where were the gulls?

A. The gulls were at varying heights from a few feet to 30 or 40 feet. Every once in a while they would swoop down, and apparently pick up something.

Q. Then the way you located the outlets was by the gulls?

A. Yes.

Q. Now, what is the character of the discharge from the Passaic Valley Sewerage project, which in your judgment is the one which is to produce the nuisance that you have testified will be produced in New York Harbor?

A. In making that statement I took into consideration the population and the amount of sewage to be delivered at the outlet, and

the amount of treatment which I understand the sewage is likely to receive.

Q. What is the amount of treatment which you understand the sewage is to receive?

A. My understanding is that the sewage is to be conveyed to a pumping station on the Newark meadows near Newark Bay. Then before it enters the pumping station from the trunk sewer, it is to pass through some relatively coarse screens. After that it
3184 is to pass through a grit chamber. From the grit chamber it is to pass through some finer screens and which will go to a series of sedimentation basins, with a rest of from an hour to an hour and a half, depending upon the period of the day. After that, after receiving this treatment of sedimentation, the sewage is to be discharged by pumps to New York Bay near Robbins Reef.

Q. After the effluent thus produced, will it or will it not when discharged into New York Bay have suspended particles visible to the naked eye?

A. It will.

Q. And will it produce an odor at the point of discharge?

A. It will.

Q. Will there be grease and color perceptible at the point of discharge coming from the sewage?

A. I shall expect to find them there.

Q. Will it perceptibly decrease the oxygen content of the water of New York Bay in your opinion?

A. It will increase the present tendency of loss of oxygen in the Bay.

Q. That is practically the same thing as my question is it not? And will it be injurious to health the effluent I mean?

A. It will increase any condition that may now be injurious to health in the Bay.

Q. Well, why do you say you understand that is the character of effluent that is to be discharged from this sewer confining it entirely to the processes that are contained in the stipulation?

A. I have never heard any other process was contemplated.

Q. I know, but you know the stipulation guarantees that certain results will be produced, don't you?

(Witness examines stipulation.)

Q. Look at the second paragraph there?

A. Yes, I see that this says that they will be produced.

3185 Q. You think that the processes as defined will not produce that effluent?

A. I should say not.

Q. Is it feasible to produce an effluent which will embody or entail the results that are guaranteed in that stipulation, being Complainants' Exhibit No. 135?

A. I should say it would be possible.

Q. Why do you say the discharge contemplated is not the discharge as guaranteed by the State of New Jersey, and Passaic Valley Sewerage Commissioners in this stipulation?

A. I should say that the plant described in the stipulation could not possibly secure those results.

Q. I understand that Mr. Provost, but you say that the effluent that is contemplated will not produce the results and I want to know why you say that is not contemplated when the stipulation guarantees that it shall be produced. How do you know that it is not contemplated?

A. I have no definite knowledge of what is contemplated except what is in the stipulation.

Q. You see that in that stipulation the results are guaranteed, do you not, you see that, don't you?

A. I see the stipulation calls for results.

Q. Guarantees, the parties named the Passaic Valley Sewerage Commissioners and the State of New Jersey guarantee certain results you see that?

A. That is provided it could be shown that these results were not obtained.

Q. Well, where do you see that? Will you point out where any such provision appears?

A. This stipulation must be enforced I suppose.

Q. That is not the question. You put in the proviso there. Now will you point out the proviso?

A. I must assume that if this plant is built as contemplated in this stipulation and if after that there should be any doubt
3186 as to whether they did comply or not, there would be serious doubt in my mind as to whether it could be shown that there was compliance or non-compliance.

Q. Yes, I understand that, but when you testified as I understand you to the effluent or the discharge as contemplated, that it would create a nuisance, I want to understand where you get your foundation for that understanding as to what is contemplated?

A. I am assuming that the plant will be built as described in this stipulation.

Q. You are assuming that, that is quite right. Now, what else are you assuming. Do you assume that the plant will produce the guaranteed results or do you assume that it will not?

A. I assume that that plant will not produce those results.

Q. And for that reason you assume that the State of New Jersey and the Passaic Valley Sewerage Commissioners do not contemplate carrying out this stipulation, do you?

A. I should not say that, no.

Q. Well, why not? What are they going to do, carry it out?

A. I should say it might be difficult for anybody to say whether they were carried out.

Q. That has nothing to do with what is contemplated. I want to know where you get the conclusion that they contemplate violating the stipulation?

A. My interpretation of that stipulation, without going into the legal side, would be that a plant will be built such as described there, and if it is found afterwards that it did not comply, then the other clauses of the stipulation would apply, if they were practicable.

Q. They are practicable, are they not?
A. If the necessity for them is obvious.
Q. I am not saying anything about the necessity. I am asking you if they are practicable in your judgment?
3187 A. I think the plant could be built that would comply.
Q. And do you know of any way of disposing of the Passaic Valley sewage, so that there will not be a nuisance to the people of Newark Bay or the Passaic River, or as you have testified in New York Harbor?
A. Do you know of any way?
Q. Yes.
A. I think if I were employed to find a way, I might find it.
Q. Do you know at this present moment, does any way suggest itself to you other than producing an effluent such as is specified there?
A. There are several ways of doing it. The steps described here are merely the beginning of sewage purification.
Q. You would add something to them?
A. It would be necessary to add to them.
Q. Then that would give you an effluent that would produce these results?
A. I think they could be secured.
Q. Why do you say that the Passaic Valley Sewerage Commissioners and the State of New Jersey are not going to produce those results, do no- contemplate producing them?
A. I do not think that I testified to that.
Q. You have testified as to the contemplated discharge which you said would produce a nuisance?
A. As I understand the plans to be.

Mr. Riker: That is all, Mr. Provost.

Redirect examination by Mr. O'Sullivan:

Q. How about the cost of a plant capable of securing such an effluent. Would you consider the cost prohibitive or moderate?

Mr. Riker: There are some degrees between prohibitive and moderate.

Mr. O'Sullivan: I am giving him latitude enough. There the stipulations are ambiguous.

3188 A. I should consider the cost very extensively burdensome to the territory.
Q. Mr. Provost, you were asked as to whether certain of these outfalls, whether at the discharging point the discharge pipe was horizontal or vertical. Does it make any particular difference as to whether they are vertical or horizontal?
A. Not in my opinion.
Q. Will the sewage still rise to the surface?
A. It will rise to the surface irrespective of that.
Q. No matter how it is discharged?
A. Irrespective of the shape or elevation of the discharge.
Q. You located some of these—or rather their location was evi-

dent you stated from the boiling up of discolored water. Will you describe in some other way what you mean by the boiling up?

A. This action which I referred to was most noticeable at the Deer Island outfall. A small boat there would have been severely rocked by the bouyancy of this sewage as it came up through the salt water in which it is discharged. As I recall it that crater of water was probably 20 feet in diameter, and it was I should judge 18 inches high above the surrounding water. It came in a sort of series of fountains. There was no spray but there was a movement, a distinct aggressive movement to the water above this outfall. At the Nut Island outfall, the motion of the water was much less marked, but it still was marked. It is very plain, but the area, both the area and the height of the disturbance was materially less than at the Deer Island outlet. Of course the amount of sewage is very much less also, only about one third.

Q. Was the sewage area immediately adjacent to the outfall in every case elevated above the surface of the water?

A. Yes, in every case. At Moon Island the material enters the tide from a superior elevation. It rushes down and feeds
3189 itself out on top of the surface of the harbor, and was noticeable in a distinct moving stream on account of the impetus which it received coming from these elevated storage tanks.

Q. A moving stream in what direction?

A. A stream moving seaward.

Q. Did you need a chart or sextant or azimuth compass to locate that seething mass of sewage as it came up?

A. No, nothing was necessary besides the general knowledge of the locality there and a small map of the harbor which I had with me to identify the islands and other geographical points. The sewage from the Moon Island discharge spread out in the shape of a fan, after it left the outfall, and the fan divided as it approached Long Island, which runs about north east and south west, as I recall it, quite a long island, and this fan divided into two fingers, one of which ran to the north of Moon Island, the other running on to the south side, the southerly one ran down towards the Nut Island outlet and the northerly one ran down towards the Deer Island outlet.

Q. Do you describe these fingers of sewage that you have just now testified to as sewage fields or dispersion areas or any such term?

A. Well, they might be called sewage fields and dispersion areas.

Q. Did you notice in addition to that any sleek fields as the result of this boiling mass of sewage that came up as you have described?

A. The sleek field carries considerably further than the discolored water surface. The grease seemed to spread out into a very thin film, which went further than the discoloration in all cases.

Q. Were you appraised of the vicinage of these outfalls by the odors in addition to the elevation of this seething mass of sewage?

A. Yes, the outfall at Deer Island, where the discharge is continuous, was very noticeable. One would notice that easily at

night, passing in a boat. The odors at the Nut Island dis-
3190 charge were much less noticeable, and in fact I do not think that at a quarter of a mile away on the leaward side, there will be anything noticeable at all. In the direction in which the wind came, those odors would be noticeable at long distances. At the Moon Island outlet the odor there was extremely putrid and sickening, and that could be detected at a long distance. The sewage field was accompanied by strong odors for a mile and a half from Moon Island outlet.

Q. You mentioned something about gulls, Mr. Provost. Are they indicative of sewage areas and sewage fields insofar as they are ordinarily in the neighborhood of such areas?

A. Well, the gull is a scavenger and feeds on decomposing matter, and they are usually found around floating masses of sewage.

Q. In what condition would you expect the sewage as discharged from the Passaic Valley Trunk Sewer outfall to be as to its age?

A. I should expect the sewage from the Passaic Valley trunk sewer by the time that it reaches Robbins Reef, to be in an extremely putrid condition.

Q. May sewage contain sufficient organic matter in solution and yet be devoid of suspended particles so as to be highly putrescible?

A. It may.

Q. Is colloidal matter putrescible?

A. Part of it is.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. You do not agree with Mr. Jackson as to the condition of the Passaic Valley sewage when it will be discharged at Robbins Reef. You heard him testify that it would be fresh, did you not, it would not be septic, at any rate?

A. I think it would be quite putrid.

Q. You do not agree with him?

A. Apparently not, if he thinks it will be fresh.

Q. You heard him testify?

A. Part of his testimony.

3191 Q. You heard him say that it would not be septic, did you not?

A. That was my understanding that he so testified.

Q. Well, you say the purification of the Passaic Valley sewage, so as to produce the guaranteed results will be burdensome. Just what do you mean by burdensome?

A. I mean that it would involve a tax upon the people benefited which would probably be very difficult for them to pay.

Q. Convert it into dollars and cents please. How much money do you think it would be necessary to expend in the plant in the first place to produce the results?

A. Well, I should hesitate to give any estimates of the cost of that without considerable study. It is my opinion without such study, I should say it would cost a great many millions of dollars.

Q. Do you know whether the sewer as now protected by the

Passaic Valley Sewerage Commissioners is burdensome or not upon the territory?

A. I should say from what I have heard of the estimate it probably would be somewhat burdensome.

Q. And an increase in the processes or in the cost of the plant, or in the cost of the treatment of the sewage will make it more burdensome?

A. Make it more burdensome.

Mr. Riker: That is all.

Mr. O'Sullivan: That is all, Mr. Provost.

Adjourned to September 17, 1912, at 10:30 A. M.

3192 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, Sept. 17, 1912—10:30 o'clock a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

HERBERT D. PEASE, a witness called on behalf of the Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name?

A. Herbert A. Pease.

Q. And what is your occupation?

A. Bacteriologist and sanitary expert.

Q. Where did you graduate?

A. I graduated in medicine from the University of Toronto in 1893, was a post-graduate student and Fellow in Pathology in the Johns-Hopkins University and hospital from 1893-1895. I
3193 was first assistant bacteriologist of the Bureau of Pathology, Philadelphia from 1895 to 1898. I was Pathologist of the New York State pathological laboratory, University of Buffalo, from 1898 to 1900. I was instructor in bacteriology, Sheffield School, Yale University in 1901. I was director of the Hygienic Laboratory, New York State Department of Health from 1901 to 1909.

From 1909 to date I have been consulting bacteriologist and sanitary expert, having office at 39 West 38th Street, New York City. In January 1911, I was appointed sanitary expert of the Board of Water Supply of New York City and still hold that position.

Q. Have you had any special training and experience bearing on the problems involved in these pollution cases in the State of New York and the State of New Jersey?

A. In 1894 and 1895 I made special bacteriological investigations of the Schuylkill and Delaware Rivers in connection with the studies of the water supply of the City of Philadelphia. During this same period, I made an investigation and presented a special report to the Bureau of Health of the City of Philadelphia, of a large outbreak of typhoid fever and demonstrated that the same was due to the direct pollution of the public water supply of that City by the overflow of the sewer.

From 1904 to 1905 inclusive, I personally investigated and made special reports to the State Commissioner of Health of New York, on all the large outbreaks of typhoid fever which occurred in that State during those years.

The investigations of these outbreaks led to bacteriological investigations of the pollution of practically all of the large rivers and streams in the State of New York, including the Niagara River, Oswego River, Black River, St. Lawrence River, Mohawk River and the Hudson River as far south as Poughkeepsie. During this same period, there were made under my direction, special investi-
3194 gations, bacteriological in character, of the water supplies of all the important cities and villages of the State of New York irrespective of outbreaks of typhoid fever.

In 1908, while still in charge of the Hygienic Laboratory of the State Department of Health, I was directed by the State Commissioner of Health to supervise a special sanitary investigation of the oyster beds and water adjacent thereto in the State of New York.

Since May 1910, I have carried on systematic and special investigations of the oyster beds owned or controlled by the Sealshipt Oyster System of South Norwalk, Conn., and Boston, Massachusetts. Such beds were located in the States of Massachusetts, Rhode Island, Connecticut, New York and Virginia. I have also had sanitary supervision over the methods employed in the production, handling, packing and distribution of oysters by the Sealshipt Oyster System, beginning with the month of June, 1910 and extending until the middle of June, 1912.

I have carried on similar work for other large producers and distributors of oysters whose beds have been located in the States of New York, Rhode Island, Connecticut and Virginia. Under my direction and supervision, sanitary investigations have been made of oyster beds in the waters of the States mentioned, and samples of oysters and of the waters adjacent to oyster beds have been collected and examined under my direction in the Lederle Laboratories.

I have acted as a special adviser on scientific and sanitary matters to the Board of Directors of the Oyster Growers and Dealers

Association of North America during the years of 1910, 1911 and 1912.

Since June, 1911, I have made special studies and have supervised the investigations of a bacteriological character on deep sea and surface feeding salt water fish. This work has been carried on
3195 for a Committee of the Allied Salt Water Fish Industries, representing some of the large fish interests of the Atlantic coast.

During my connection with the New York State Department of Health and since that time, I have made many investigations and studies of the causes of outbreaks of typhoid fever, diphtheria and other communicable diseases, which have been determined to have been due to conditions of pollution of waters or the contamination of shell fish.

Q. Are you connected with any medical societies, Doctor?

A. I am an active member of the Medical Society of the County of Albany, an Honorable member of the Medical Society of the Counties of Rochland and Dutchess. I am a member of the New York State Medical Society and the American Medical Association. I am an active member of the American Public Health Association and am Secretary of the Sanitary Engineering Section of the same. I was Recorder of the Laboratory Section of this Association for ten years and have been for the past three years the Secretary of the Committee of this Section appointed to formulate standard methods for the sanitary examination of shell fish. I am a Charter Member of the Society of American Bacteriologists and American Association of Pathologists and Bacteriologists. I am a member of the following associations: American Association for the advancement of science; Associated Physicians of Long Island; New England Water Works Association; National Association for the study and prevention of Tuberculosis. I am also a Fellow of the New York Academy of Medicine and am at the present time the Secretary of the Section on State and Municipal Hygiene of the International Congress on Hygiene and Demography, 1912 meeting.

Q. Are you familiar with the testimony that has been given in this case?

A. I have read in full the testimony of Complainants' witnesses as to the methods of conduct of the float experiments which have been presented graphically in Complainants' Exhibits 4, 5, 6, 7, 8, 9, 10, 11, 61 and 62.

3196 Q. Have you made examination and studies of the testimony of the previous witnesses given for the Complainants?

A. I have.

Q. State to what extent, Doctor?

Mr. Riker: The question is objected to as an improper way of calling for testimony in the case, as being immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: I withdraw the question.

Q. Have you made any personal inspections of the waters of New

York Lower Bay, especially those in the neighborhood of the Great Kills and on the Staten Island shore?

A. I have.

Mr. Riker: Excuse me, Doctor, I give notice of motion to strike out all that testimony as being founded admittedly on hearsay.

The Commissioner: Note the motion of Counsel for Defendants.

A. On July 13th, 1908, I made an inspection of the waters of this region with the special object of determining by personal observation and by interrogation of experienced oystermen and sailing masters of vessels engaged in the oyster industry, as to the general directions of tidal currents in the waters of the Lower Bay, and with the particular object in view of determining whether the sewage passing from the upper to the lower bays during the ebb tide would, under average conditions, be carried directly to the oyster beds south of Great Kills, or would be indirectly carried to this same region. As a result of this inspection and of the information gathered by me personally at that time, I arrived at the conclusion that the sewage polluted waters passing through the Narrows on the ebb tide would, under average conditions as to winds and
3197 tidal currents, not pass directly over the oyster beds south of Great Kills, but that the presence of any sewage polluted waters in the vicinity of Sandy Hook at the turn of the ebb tide would, as a general rule, be carried back upon the flood tide, at least in part, to the oyster grounds south of Great Kills.

Mr. Riker: The same motion in regard to that testimony.

The Commissioner: Note the motion of Counsel for Defendants.

Mr. O'Sullivan: That excludes his own observations that have been described?

Mr. Riker: The motion only extends so far as the motion itself indicates.

Q. Proceed, Mr. Pease?

A. On May 4th, 1910, in company with the officers of the Sealshipt Oyster System, I made a tour of inspection of the waters south of Great Kills, Staten Island and again investigated this same problem, both by personally observing the direction of the current of the incoming tide, which on that day reached full flood during the latter part of the afternoon, and by personally conferring with A. K. Cole, Vice President of the Sealshipt Oyster System, in charge of the oyster grounds of that company south of Great Kills and determined again that the general trend of the flood tide was from Sandy Hook in a northwesterly direction to the oyster beds south of Great Kills. On this trip, various stops were made by the steamer and oysters were dredged. While the engines of the boat were not in motion, the steamer was carried by the force of the tidal current and always in a northwesterly direction.

Q. Doctor, you state that you were directed by the State Commissioner of Health to plan and supervise a complete investigation of the sanitary conditions of the oyster beds in New York
3198 State waters in 1908. Will you state the reason why you undertook these investigations?

Mr. Riker: The question is objected to as being based on hearsay testimony and not relevant or material to this issue.

The Commissioner: Note the objection of Counsel for Defendants.

A. This investigation was undertaken in compliance with Section 214 of the Forest Fish and Game Law, then upon the Statute Books.

Mr. Riker: I move to strike this testimony out as being an attempt by this witness to testify as to what the law of the State of New York is.

The Commissioner: Note the motion of Counsel for Defendants.

Q. Will you state whether you had any help and assistance in this investigation?

A. I had the assistance and co-operation of the Engineering Division of the New York State Department of Health, under the supervision of Mr. Theodore C. Horton, Director of that Department.

Q. What portion of the work in this investigation was actually conducted by the staff of the Engineering Division of the State Department of Health?

A. The detailed sanitary inspections of all the shores, bordering upon the tidal waters and the streams running into the same, the making of special determinations as to the direction of tides and currents.

Q. What portion of the investigation was made directly under your supervision?

A. The collection and bacteriological examination of samples of water and of shell fish. These collections and examinations were planned by me in conference with the chief chemist of the State Hygienic laboratory, and the work was conducted under the immediate supervision of the chief chemist, Mr. L. M. Wachter.

3199 Mr. O'Sullivan: I withdraw this witness for a moment until I put Mr. Wachter on the stand.

LEONARD M. WACHTER, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Are you connected officially with any of our State Departments, Mr. Wachter?

A. I am Sanitary Chemist of the State Department of Health.

Q. Are you Chief of the Chemical staff?

A. I am.

Q. Where did you study?

A. Rensalaer Polytechnic Institute, Troy, New York.

Q. Professor William P. Mason, was he a teacher in that Institute at the time that you studied there?

A. He was. He was my Professor in Chemistry at that time and I learned my sanitary water chemistry under him and he was considered one of the fathers of Sanitary Water Chemistry.

Q. You heard Dr. Pease testify?

A. I did.

Q. Now, will you detail the special features of the investigation that you conducted, stating how you secured the samples of both oysters and water and what you did with them?

A. That is relative to this specific location?

Q. Yes.

A. I made one trip to the vicinity of Raritan Bay, that is the vicinity of the Great Kills and from there around to Tottenville, with Dr. Pease, and a Mr. Merrell, who was an oysterman, having oyster beds in that vicinity, and at that time we observed the general conditions so as to plan the laboratory work. Later a laboratory was established at the Brooklyn Polytechnic Institute, and I personally accompanied by a laboratory assistant and the same Mr. Merrell, and a captain who ran the boat,—I have forgotten his name, but he was a partner of Mr. Merrell in these particular
3200 oyster beds owned by Mr. Merrell in that locality. We went out and collected samples of water and of oysters from Great Kills in a general southerly direction to the south point of Staten Island and samples of water were taken from across the mouth of the Arthur Kill, from the point of the Southern extremity of Staten Island off the Jersey shore in the vicinity of Cheese Creek.

Q. What did you do with these samples, the samples of oysters when you raised them to the surface of the water. What next did you do with them?

A. I had a map, a Government map of that locality, and by the aid of the captain of the boat, who as I said before, knew the location of the individual beds, located on the map the points, using the stakes, showing the oyster men's individual holdings, and the Government light and the points on shore as references, in that way we fixed the point from which the samples were taken and located them on the map.

Q. One moment, have you got that map with you?

A. Yes, sir, I have it here.

Q. And those writings on that map are they in your handwriting?

A. Yes, sir, they are. There are lead pencil figures that are in my handwriting, and they are the field figures that I put down at the time that the samples were taken. At a later time in my own handwriting, ink indications were placed on those points indicated by lead pencil at the time that the work was done.

Q. Is that map part of the state records of your department?

A. Yes, sir, it is the map upon which the locations were taken that are shown in the published reports of this investigation.

Q. Have you got a duplicate of that map?

A. I have here a printed copy showing the details, and I have compared the locations and the numbers on this printed copy with the original map which I made in the field.

3201 Q. And how do they compare?

A. They agree.

Q. Is it a correct copy? It is as far as one is able to judge by the eye, yes, sir, it is. The figures and the locations agree.

Mr. O'Sullivan: I offer that map in evidence and ask that it be marked Complainants' Exhibit No. 181 in evidence.

Mr. Riker: Which one are you offering, Doctor?

Mr. O'Sullivan: The copy. I am not permitted to offer the other.

Cross-examination by Mr. Riker:

Q. You say this is in your opinion a copy of the original?
A. Yes, sir.
Q. Is it the same size?
A. No, sir, it is not.
Q. Does it contain the same detail?
A. It does.
Q. In all respects?
A. In all respects as one is able to judge by the eye.
Q. Will you hand me the original please. (Counsel examines the original.)
Q. I draw your attention to the portion of the original map marked "Upper Bay" and I ask you whether the figures that appear there are reported on what you claim to be a copy?
A. No, sir, they are not.
Q. And in the Lower Bay, are the figures that appear on the original reported in the copy?
A. No, sir, they are not.

Mr. Riker: I object to the offer on the ground that it is not a copy and is not properly proved.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: Complainants' Counsel desires to state that this map is offered not as an exact duplicate of the original map, but for the purpose of showing the oyster beds located in these waters and from which he obtained samples.

3202 Direct examination by Mr. O'Sullivan (resumed):

Q. Do the locations from which you obtained the samples appear accurately on this copy of the map?
A. They do, as far as I am able to judge by the eye, and the numbers indicating the sample stations are there. The water depths are not located on this copy.

Mr. O'Sullivan: I renew the offer.

Mr. Riker: I renew the objection.

The Commissioner: Note the objection of Counsel for Defendants.

Received and marked Complainants' Exhibit No. 181.

Marked Complainants' Exhibit No. 181.

Q. You may proceed and tell what you did with the oyster samples that you took from these locations that are indicated on this exhibit, Complainants' Exhibit No. 181?

Mr. Riker: The question is objected to because it does not appear that he took any oysters from points shown on this exhibit.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Did you take oysters from the locations indicated on Complainants' Exhibit No. 181?

A. I did.

Q. State what you did with them when those oysters were raised to the surface of the water?

A. When the oysters were taken out of the water, the oysters from a given point were put into an individual tin can. That had a screw cap cover. In the can along with the oyster was placed a tag, and on that tag was the same number that was placed upon the map. The cover of the box was then closed and after the series of samples were taken from a number of locations, the boxes containing the individual series, were, when in my possession, or that of my assistant, carried to Great Kills, and in some instances by boat to Tottenville, where the train was taken and they were
3203 brought to Brooklyn by me and my assistant, and immediately upon arriving at the Polytechnic Institute, where our laboratory was located, the samples were placed in refrigerators for the night.

Q. What did you next do with those samples of oysters?

A. The following morning after the samples were taken, the oysters selected from any given sampling point were scrubbed with a brush and thoroughly cleaned with tap water. After they were so washed and dryed with a towel, at a point on the oyster shell near the hinge where the oyster shell usually forms the deepest cavity, it was flamed with a Bunson gas flame to sterilize it. A steel drill was then sterilized in the same manner by flaming it with the gas flame and a hole was drilled partly through the oyster shell. After the hole was partly drilled through the drill was freed from the chips of oyster shell and again flamed with the Bunson flame, and the oyster shell also flamed the second time with the gas flame. The hole was then drilled completely through to expose the interior of the oyster shell. With a sterile pipette, or with sterile pipettes, different volumes of the oyster liquor were taken out, and either inoculated directly into Jackson's bile media, or else diluted with sterile water and those dilutions placed into the bile media for fermentation. These inoculations of oyster liquor, or the dilutions of the oyster liquor were then incubated in an incubator to find if fermentation of the lactose contained in the media took place. If fermentation did take place, with a sterile platinum loop, portions of these cultures were inoculated into lactose azolitmin agar plates. If the colonies that grew in or upon these azolitmin agar plates were typical red colonies it was considered that the oyster liquor in the fermentation tube contained organisms of the B. Coli type.

Q. Who was the Dr. Jackson that you mentioned?

A. Dr. Jackson is Dr. Daniel D. Jackson,—I know his
3204 name is Daniel. I think the second initial is D. He is director of the Mount Prospect Laboratories of the Department of

Water, Gas and Electricity of New York City. He is the one who worked out the socalled Jackson bile media, which is now and was at that time recognized as the standard media for the isolation of B. Coli by the American Public Health Association in standard methods for water analysis.

Q. Were you with Dr. Pease on any of his tours of inspection of the waters of the Great Kills?

A. I previously testified that Dr. Pease accompanied me in my first trip to the Great Kills along with Mr. Merrell who was an oyster man with interests at that point, and a captain, who I was told at that time was his partner, who operated the boat.

Q. Did you make other trips by water or otherwise to the section you were just testifying about for the purpose of collecting samples of oysters for bacteriological examinations?

A. I took many series of samples and each series as I remember would take more than one day. That is we only took on a given day the number of samples that could be handled in the laboratory the following day.

Q. Were these examinations under your immediate supervision and did you participate in the making of them?

A. The local laboratory, by that I mean the one at Brooklyn, because the Department laboratory was at Albany, was under my immediate supervision, and all the work was done by me and my immediate assistants. All the samples collected were made in my presence and I accompanied the samples each time to the laboratory.

Q. Did you have charge of the recording of the results of these examinations, and did you participate in the preparation of the official report showing the results of these examinations?

A. The records were entirely in my charge until the work was completed, and the laboratory equipment and records taken to Albany, and I participated in making the reports.

3205 Q. And did you submit the report of the results of these examinations of the samples which you collected from the waters of Raritan Bay and Great Kills and that vicinity?

A. I reported them direct to Dr. Pease who was director of the laboratory, and my immediate chief.

Q. Mr. Wachter, does any official state report contain a description of the methods employed by you and under your supervision for the bacteriological examination of the samples of water and oysters?

A. To my immediate knowledge at the present time, I do not think there was, except that the reports state the indications of the tables, contain tabulations of the results.

Q. Does any official report contain the tabulations of the results of your examinations made by you of the samples of water and oysters collected by you from the waters of Raritan Bay and the Great Kills and that vicinity?

A. The 29th Annual Report of the State Department of Health, Volume 2, for the year 1908, contains a report of the oyster investigation and as part of that report are the tabulations concerning

the results of the laboratory findings on samples of water and oysters, taken from Great Kills and vicinity.

Q. By you?

A. Yes, sir. The samples and the work was done by me and my assistants.

Q. Mr. Wachter, I direct your attention to Complainants' Exhibit No. 181, and ask whether there are indicated on that exhibit the approximate locations of the points from which the samples of water and oysters were collected by you and under your supervision during the investigation you have just testified to?

A. They are.

Q. In what way?

A. They are indicated by circles, some solid and some simply a dark ring and an arrow pointing to these circles direct- attention to the numbers. These numbers are followed each by a decimal point,

3206 and the decimal 1 or the decimal 2 indicates respectively the sample number or either water sample or the points from which oysters were taken, .1 indicating water samples, and .2 indicating the oyster sample stations.

Q. Mr. Wachter on what page of Volume 2 of the 29th Annual Report of the State Department of Health of the State of New York for the year 1908, do the tabulations that you have just testified to as representing your work appear?

A. They appear on page No. 892.

Mr. O'Sullivan: Instead of offering this entire volume which contains much irrelevant matter to the purpose of my present inquiry, I offer that portion of the 29th Annual Report, Volume 2 for the year 1908 of the State Department of Health of the State of New York, I offer that portion of it, which I have had separated out from one of these reports dealing entirely with the sanitary inspection of the shell fish grounds that have been testified to. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 182.

Mr. Riker: What do you know about this offer, Mr. Wachter?

The Witness: I do not know anything about that particular thing.

Mr. O'Sullivan: Leave the stand a moment, Mr. Wachter. I withdraw my offer.

HERBERT D. PEASE, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. I hand you what purports to be the 29th Annual Report of the State Department of Health of the State of New York, Volume 11 for the year 1908, and ask if you separated from a similar volume that portion of the volume that deals with the sanitary inspection of shell fish grounds?

A. I did.

3207 Q. Have you got it with you?

A. I have.

Q. Did you have that portion of the volume separately bound?
A. I did.
Q. And it contains no other matter than the maps and tabulations of the work of the sanitary investigation of the shell fish grounds?
A. None whatever.

Mr. O'Sullivan: I offer this in evidence and ask that it be marked Complainants' Exhibit No. 182.
Mr. Riker: The offer is objected to as being immaterial and irrelevant, the matter supposed to be introduced in this form not having been proved in any way by any witness competent to testify to it.
The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 182.
Marked Complainants' Exhibit No. 182.
Mr. O'Sullivan: That is all, Doctor.

LEONARD M. WACHTER a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. I now direct your attention, Mr. Wachter, to page 892 of Complainants' Exhibit No. 182. I ask you if you personally compiled the results of the investigations which appear on the table on page 892?
A. I did.
Q. Now, before the State Department finally issued that tabulation in the form in which you have it in your hand, was the proof of the report, of that portion of the State Department report, submitted to you, and did you compare it with the original notes showing the results of the examinations of the samples obtained from Raritan Bay and Great Kills and vicinity, and were they corrected?
3208 A. I compared the results in all portions of the report which refer to the oyster investigation.

Mr. O'Sullivan: That is all. You had letter cross examine this witness. I had to get him down last night from Albany on a hurry call.

HERBERT D. PEASE a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. You heard the testimony of the preceding witness, Mr. Wachter?
A. I did.
Q. Were the results of the investigation carried on under your supervision and his immediate direction, insofar as the bacterial examinations of samples of waters and oysters from the Raritan Bay and the Great Kills and vicinity transmitted by him to you?
A. They were.

Q. Did you include that in any official report made by you as the result of this investigation?

A. I did.

Q. Will you examine Complainants' Exhibit No. 182 and state whether it contains the report made by you of this investigation?

Mr. Riker: The question is objected to because of the use of the so-called exhibit, the exhibit not having been properly proved or admitted.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Proceed, Doctor?

A. Beginning with page 834 and including the intervening pages to the bottom of 861, and then beginning a new paragraph at the bottom of page 862 and extending to the end of the first paragraph on page 864 contains portions of the report actually written by me.

3209 The results presented on page 892 under the title "Oyster Cultivation, District No. 14, Raritan Bay," were transmitted by me to the Engineering Division of the State Department of health and were finally incorporated in the Appendix to the Report which was prepared by that Division, beginning Page 865. However, the proof sheets of this entire report were submitted to me prior to publication and were carefully scrutinized and the tabulated results were transmitted to Mr. Wachter for comparison with his original notes.

Q. Have you examined the tables appearing on pages 58 and 56 of Complainants' Exhibit No. 2, being the report of the New York Bay Pollution Commission dated March 31st, 1905?

A. I have and I have also read with care the statements appearing in Exhibit 2, beginning at the bottom of page 48 and continuing to the bottom of page 57.

Q. You have testified that you made investigations of the sanitary conditions and surroundings of the oyster beds owned by a number of your clients?

A. As already stated in my testimony, I have made a large number of special investigations in many parts of the country, but I have given special attention to the investigations of the sanitary surroundings and the actual conditions of oysters in certain locations, among these being the oyster beds off Great Kills.

Q. Will you describe the investigation that you made off Great Kills?

A. Investigations of the oyster beds and the surrounding waters for my clients, have consisted in the following procedure; first—a thorough examination of all the official and other records showing the results of any previous bacteriological or sanitary investigations

3210 on such oyster grounds, second—a thorough study of all available documents, official and otherwise, which would give information as to the direction of tidal and other currents and as to the meteorological conditions at seasons of the year when oysters are taken from oyster beds for transportation to market, and in genral, a study of all the data which would enable me to arrive at a

conclusion as to the amount, if any, and character of pollution of the waters coming in contact with such oyster grounds. Where sufficient information could not be obtained as to sanitary conditions from official documents, complete sanitary inspections of the surroundings of these oyster beds and the territory adjacent thereto, would be made by my assistants or my associate sanitary engineer, Mr. A. J. Provost, Jr.

Following the studies of documents, it has been my custom to make one or more personal trips of inspection, to note the general surroundings and character of the waters over the oyster beds, and to hold consultations with captains of oyster boats and pilots and others familiar with the tidal and other currents, and the directions of the wind in such locations.

Still later, samples of oysters are collected, either by members of my own staff or the collection of the same is requested of the client. When the collection is requested of clients, blanks are furnished to them, giving directions for collecting oysters and samples of water for bacteriological examination; and also calling for data relating to the surroundings of the bed from which the samples are collected. I desire to submit two copies of these blanks, as part of my testimony.

Q. What information is called for in the blanks that you would submit?

3211 Mr. Riker: The question is objected to as immaterial and irrelevant, the only competent inquiry being what has been done, not what has been called for.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Have you got any of those blanks with you, Doctor?
A. I have.
Q. And you produce them?
A. I do.

Mr. O'Sullivan: I offer one of these blanks in evidence and ask that it be marked Complainants' Exhibit No. 183.

Mr. Riker: The offer is objected to on the ground that this blank has not been made competent as bearing in any way on the issues in this cause.

The Commissioner: Note the objection of Counsel for Defendents. Received and marked complainants' exhibit No. 183.

Q. Proceed.

A. It should be noted that information is called for by the blank, giving data concerning the condition of the tide at the time the sample is collected, the direction and velocity of the wind, and the character of the weather; also information as to the character of the bottoms from which the samples of oysters are taken and the depth of water over the same.

Upon the collection or the receipt of the samples of water or oysters, the methods to be pursued in the examination of samples and of recording the results of the same and of recording the data sub-

mitted by the collector of the sample, as definitely laid down by me, are pursued by my assistants and upon the completion of all examinations, the results of the same, together with all the data and information which has been collected, are re-submitted to me for final interpretation and report.

Q. Now, have you adopted that procedure in any special
3212 investigations of the oyster grounds and the oysters taken off the Great Kills for your private plans?

A. I have. Copies of these blanks have been submitted to all interested in the collection of the samples, and have been filled out by them and have been returned to the laboratory and were used by me in the drawing of final conclusions and interpretations as to the sanitary significance of the results of the examinations.

Q. Did you make any inspection trip in 1910?

A. Yes, and I have already so testified and have given testimony as to the results of personal inspection of the waters of that region made on May, 4th, 1910. Prior to that inspection, I made a thorough study of the official reports of the New York Bay Pollution Commission of 1905-1906, and again carefully reviewed the results of the investigation which had been made under my supervision of the oyster beds and oysters of this region in 1908 for the State Department of Health.

Following the inspection trip in 1910, I requested of my clients that they designate one of their employees who was thoroughly familiar with the Great Kills oyster grounds to make collections of samples of water and of oysters from the various beds owned or controlled by them, and to authorize him to make such collection at such times and under such conditions as I would subsequently indicate. They designated for this purpose Mr. George W. Sanbeg of New Dorp, Staten Island and Mr. Sanbeg has been requested by me to make not only special, but routine collections of samples of water and oysters from special sections of particular beds and likewise to make observations as to the temperature of waters over these beds and to make notes as to the direction and velocity of winds blowing at the time samples are collected, and the state of the tide.

3213 Mr. O'Sullivan: I will withdraw this witness for a few minutes and call Mr. Sanbeg.

GEORGE W. SANBEG a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Where do you reside, Mr. Sanbeg?
A. Great Kills, New York.
Q. And that is on Staten Island?
A. Yes, sir.
Q. And what is your occupation?
A. Oyster man.
Q. What experience have you had Mr. Sanbeg in the navigation

of the waters of Lower New York Bay, especially the waters of the Great Kills and in Princess and Raritan Bay?

A. I have been around those waters continually for this past 30 years.

Q. What do you know as to the condition of the waters over the oyster beds of the Great Kills during the flood tide?

A. I do not understand the question. Sometimes it is rough and sometimes it is smooth.

Q. Well, I more particularly wish to inquire relative to the condition of the currents on the ebb tide, as to the observations that you made?

A. The way the ebb tide runs you mean?

—. Yes, with regard to the Great Kills?

A. Well, it runs out of the Great Kills, but a short way, a mile or so, and it runs down towards Sandy Hook, toward Perth Amboy.

Q. Are you familiar with oyster culture in the waters along the shores of Staten Island?

A. Yes, sir.

Q. What is the direction of the flood currents in the neighborhood of the Great Kills?

A. Well, off shore aways, where the Great Kills does not affect it, it comes directly from Sandy Hook. When you get in towards the Kills, of course, it is running in the Kills in the harbor.

3214 Q. How are the oyster beds indicated in that region?

A. Stakes and buoys.

Q. Who sets out the oyster beds?

A. The Engineer of the Fish Commissioners locates the corners of the various grounds.

Q. Are there stakes to indicate the lines from buoy to buoy?

A. Yes, sir.

Q. Have you collected samples of oysters at the instance of Dr. Herbert D. Pease?

A. Yes, sir.

Q. Will you state how you collected them?

A. Yes, sir.

Q. From what region?

A. Well, just west of Great Kill, southwest of Great Kills would be about the course.

Q. Are these beds numbered?

A. Yes, sir.

Q. What bed numbers did you take from?

A. No. 490 mostly. We have been taking all from 490 lately. We have taken some from the various beds at different times.

Q. Now, what did you do with the samples after you removed them from the bay, from the oyster bed?

A. Took them to Dr. Pease. That is what you mean, I suppose.

Q. Yes, just tell us how you removed them, what you did with them?

A. Put them in a boat and took them over. They were tied up sometimes in a little bag, sometimes in paper, and took them to Dr. Pease.

Q. Have you got any list that will show when you took these samples?
A. Yes, sir.
Q. Have you got it with you?
A. Yes, sir.
Q. When did you collect samples for Dr. Pease, just state, Mr. Sanlag?
A. Well, there are a lot of them here. Do you want them all?
Q. Have you got any more lists?
A. Not for 490. These are for 924 on this other list.
Q. This first list, what does it show Mr. Sanlag?
A. That shows the day that the samples of water were taken from No. 490.
3215 Q. And delivered to whom?
A. Dr. Pease.
Q. Who directed you to secure the samples?
A. Dr. Pease.
Q. And where did you deliver them?
A. To the Lederle Laboratories at 38th Street.
Q. Who prepared that list?
A. Well, I checked this up here. This here was given to me and then I compared it with my diary and with the original reports that I had surrendered with the oysters.
Q. How do they compare?
A. All right. Every one that has a check mark there, sir, is correct.
Q. What do those items show, the particular dates?
A. Yes, sir, the dates.
Q. Upon which you collected the samples?
A. Yes, sir.
Q. Does it show the time?
A. Well, not all of them. In the original report that I gave to Dr. Pease with the oysters, it does tell the time that the sample was taken.

Mr. O'Sullivan: I offer this list produced by this witness, indicating the dates on which he secured water samples for the purpose of analysis, for Dr. Pease.—I offer it in evidence and ask that it be marked Complainants' Exhibit No. 184.

Cross-examination by Mr. Riker:

Q. Is this your handwriting?
A. No, sir, only the check marks.
Q. Is it a copy of any document or memorandum in your own handwriting??
A. Well, most of it is, yes.
Q. I ask you whether it is a copy of any memorandum in your own handwriting?
A. A copy, yes, for the whole of it? Not the whole of it.

Mr. Riker: I object to the offer.

The Witness: I am willing to swear that I took samples on each of those dates.

2216 Mr. Riker: Very well, there is no objection to your swearing to that. What I object to is this particular offer on the ground that it is not evidential in the case and at best the original could but be used to refresh this witness' memory.

The Commissioner: Note the objection of Counsel for the defendants. Received and marked Complainants' Exhibit No. 184.

Marked Complainants' Exhibit No. 184.

Direct examination by Mr. O'Sullivan (resumed):

Q. This second list that you produce, Mr. Sanleg, headed "Oysters" what does that purport to show?

A. That means that I took samples of oysters on that day and date.

Mr. O'Sullivan: I offer that list in evidence and ask that it be marked Complainants' Exhibit No. 185.

Mr. Riker: The offer is objected to because there is nothing in the testimony as yet which would even tend to make it competent evidence.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 185.

Marked Complainants' Exhibit No. 185.

Q. What did you do with the samples of oysters that you just testified that you gathered on the dates as set forth in Complainants' Exhibit No. 185?

A. Took them to Dr. Pease.

Q. Where?

A. 38th Street.

Q. What laboratories?

A. The Lederle laboratories.

Q. Did you collect any other samples of water or oysters for Dr. Pease, which you delivered to him at the Lederle laboratories or elsewhere?

A. Other than those noted here?

Q. Yes.

A. Perhaps so, at different times. May be two or three
3217 years ago. I will not be sure about that. I have taken samples there at different times.

Q. Have you got a list of any of those other samples?

A. No, sir. I do not think so—yes, I have sure. Here is one for No. 924. Those are for No. 490 and they were taken at different times, and then of course at other times they were taken at other beds.

Q. These lists relate to two beds?

A. Yes, sir.

Q. Complainants' Exhibits Nos. 184 and 185 relate to what beds?

A. That is bed No. 490, yes, both of those, 490.

Q. Both the samples of water and oysters were taken from bed No. 490?

A. Yes, sir.
Q. In those two exhibits?
A. Yes, sir.
Q. Have you got lists of any other samples of water or oysters?
A. Yes, sir.
Q. That you collected for Dr. Pease?
A. Yes, sir.
Q. Have you got a list of water samples taken from bed No. 924?
A. Yes, sir.
Q. For Dr. Pease?
A. Yes, sir.
Q. And you produce the list showing the time and date of the collection?
A. Yes, sir.

Mr. O'Sullivan: I offer that list in evidence and ask that it be marked Complainants' Exhibit No. 186.
Mr. Riker: The same objection.
The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 186.
Marked Complainants' Exhibit No. 186.

Q. Do you also produce a list showing the dates and the times at which you collected oyster samples which you say you delivered to Dr. Pease?
A. Yes, sir.
3218 Q. And from what bed was that taken, those samples?
A. 924.

Mr. O'Sullivan: I offer that in evidence, the list of the oyster samples taken from Bed No. 924 produced by this witness and ask that it be marked Complainants' Exhibit No. 187.

Cross-examination by Mr. Riker:

Q. What is that a list of?
A. That is a list of oysters from Bed No. 924.
Q. Where does it say anything about oysters on that alleged list?
A. What is this at the top? (indicating.)
Q. Do you think that is a list of oysters collected, do you?
A. Yes, sir.

Mr. Riker: The offer is objected to for the same reasons, and on the ground that the exhibits shows it is not what the witness says it is.
The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 187.
Marked Complainants' Exhibit No. 187.

Direct examination by Mr. O'Sullivan (resumed):

Q. On the occasions when you took these samples of water and the samples of oysters, did you take the temperature of the water?

A. Lately, for these last 6 months perhaps.
Q. Did you note the conditions of the wind and tide?
A. Yes, sir.
Q. When you say lately, what do you mean in relation to the temperature, since when?
A. Why this last 6 months perhaps.
Q. And as to the conditions of the wind and tide?
A. We always took that.

3219 Mr. O'Sullivan: I am through with this witness, Mr. Riker. Do you want to ask him any cross questions?
Mr. Riker: No.

HERBERT D. PEASE, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Did you hear Mr. Sanbeg testify, Dr. Pease?
A. I did.
Q. As to the delivery of the samples which Mr. Sanbeg testified he gave into your custody at the Lederle Laboratories, what did you do with them?
A. I have already testified that the staff of my laboratory have and do receive from me from time to time specific instructions as to the methods to be pursued in the examination of samples of oysters and of water, and the methods to be followed in recording the results of the same, and in the recording of the data submitted by clients or that collected and recorded by members of the staff. The same course has been pursued in the handling of the samples brought to the laboratories by Mr. Sanbeg.
Q. Who had the immediate direction of the carrying out of those instructions issued by you relative to those samples?
A. My chief assistant, Mr. L. C. Himebaugh, has entire charge of the conduct of the bacteriological work of the Lederle Laboratories, under my direction. It was his duty to supervise the examinations of the samples of water and oysters brought to the laboratory by Mr. Sanbeg, and the recording of the data.

Mr. O'Sullivan: I want to put Mr. Himebaugh on the stand.

LESTER C. HIMEBAUGH, a witness called on behalf of Complainants, being first duly sworn, testified as follows:

3220 Direct examination by Mr. O'Sullivan:

Q. Where do you reside, Mr. Himebaugh?
A. At Brooklyn Manor, Long Island.
Q. What is your occupation or vocation?
A. Assistant bacteriologist and Assistant Director of the Department of Bacteriology, Lederle Laboratories.
Q. How long have you been assistant in the Lederle Laboratories?
A. Since March 8th, 1909.
Q. Under whose particular direction are you there?

A. Under Dr. Pease.

Q. Will you state where you received your education and experience and other qualifications that qualify you as a bacteriologist?

A. I received the degree of A. B. from Colorado College in June 1906, during the next two college years I completed the first two years' work at the Harvard Medical School leading to the degree of M. D. .

Q. Did you take that degree?

A. I did not complete the course. The two years' work there was directed more especially along the line of public health work. Since March 8th, as I have already testified, I have been actively engaged in bacteriological work in the Department of Bacteriology of the Lederle Laboratories.

Q. Did you hear the testimony given by Mr. George W. Sanbeg who was on the stand a few moment- ago?

—. I did.

Q. Did you receive from Mr. George W. Sanbeg samples of oysters and water and information from Mr. Sanbeg as to the condition of the tide, wind and temperature of the water at the time the samples were collected by him, which he delivered by you?

A. Either Dr. Pease or myseelf in the same place received the samples, which were delivered by Mr. Sanbeg.

Q. Did you make a bacteriological examination of any of
3221 the samples delivered to you by Mr. Sanbeg?

—. I did.

Q. Under Dr. Pease's direction?

A. I did.

Q. What method did you employ in the bacteriological examination that you conducted of these samples of water and oysters referred to?

A. The method employed in the examination of oysters was as follows: The oyster was in each case thoroughly scrubbed and rinsed in tap water. The greater portion of the edge of the oyster shell was then passed through the flame of a Bunson burner several times.

Q. For what purpose?

A. For the purpose of sterilizing the edge, in order to not introduce outside organisms into the shell liquor of the oyster in the process of opening.

Q. How did you open them?

A. The oysters were then opened by means of a sterile oyster knife and amounts of shell liquor ranging from 1 c. c. to 1/100 c. c. transferred under aseptic precautions into separate Smith fermentation tubes containing sterile lactose peptone bile. The same operation was repeated on five oysters. The Smith tubes which had been inoculated were then incubated for a period of 72 hours at 37° C. At the end of 24, 48 and 72 hours observations were made as to the presence or absense of gas in the closed arm of the fermentation tube. Where as was found, the percentage was determined. In such cases isolation of the gas producing organism was in each case attempted, by making litmus lactose agar plates from the

diluted lactose petone bile and after incubating the plates for 24 hours 37° C. colonies which resembled those of the Bacillus coli type were isolated on standard infusion agar and the following cultural characteristics determined.

First, the production of indol was determined in a 1 per cent. solution of peptone.

Second, the reduction of nitrates to nitrites was determined in a solution of nitrite free nitrates, to which had
3222 been added 1/10th of 1 per cent. of peptone.

Third, the production of gas in lactose agar was determined by making a stab inoculation of lactose agar.

The cultural characteristics above referred to were determined at the end of 4 days' incubation at 37 degrees C.

The samples of water which were received the same time as samples of oysters were examined by me or by my assistant under my direct supervision, in the following manner:

Five fermentation tubes containing a 1 per cent. solution of dextrose broth were inoculated in the following manner:

2 fermentation tubes were inoculated with 1 c. c. of water each.

3 fermentation tubes were inoculated with 1/10 c. c. of water each.

5 fermentation tubes of lactose peptone bile were inoculated in the following manner:

3 tubes with 10 c. c. each, the two remaining tubes were inoculated with 1 c. c. each.

The fermentation tubes were then incubated for 72 hours at 37 degrees C. Observations were made at the end of 24, 48 and 72 hours and when the presence of gas was observed in the closed arm of the fermentation tube, the percentage was determined and isolation of B. coli attempted in the same manner as described under oyster examination above.

A study of the cultural characteristics of the isolations made was also made in the same manner as described under oyster examination. The results obtained on these examinations by myself or by my assistant under my direct supervision, were recorded on laboratory cards printed for that purpose.

Q. How were these results arranged for interpretation?

A. The results which were obtained in the manner de-
3223 scribed above were then arranged for interpretation in accordance with the methods described for the examination of shell fish, published in the Journal of the American Public Health Association, known as the standard method for examination of shell fish.

Q. Now, to whom did you submit the results of this work that you have testified to and which you state you did under the immediate direction of Dr. Pease?

A. After making a preliminary arrangement of the findings, I referred the final interpretation of the results obtained to Dr. Pease.

Q. Did you arrange in any fashion the information given to you by Mr. Sanbeg and the results of your bacteriological determinations on the samples that he submitted?

A. I have. This information which was given to me by Mr.

George W. Sanbeg, together with the results which were obtained in the laboratories have been recorded here in the order in which the samples were received at the laboratories, and as complete information as we were able to obtain was tabulated by me in these papers.

Q. Have you checked off these tabulations with your laboratory note books?

A. These tabulations have in each case been checked with the original data submitted by Mr. Sanbeg and with the laboratory notes from each individual examination.

Q. Do you now produce a report *obtaining* the matter you have just testified to in the form in which you have testified that they exist.

A. I do.

Mr. O'Sullivan: I offer the report in the matter of the results of bacteriological examinations of samples of oysters and water collected by Mr. G. W. Sanbeg as testified to by him from the waters of oyster bed No. 490 for the Bureau of Marine Fisheries and Conservation Commission of New York State and delivered by him to this witness in the laboratory, as this witness has testified. I offer that in evidence and ask that it be marked Complainants'
3224 Exhibit No. 188.

Cross-examination by Mr. Riker:

Q. Will you take this first table and indicate what part of it represents your own personal work?

A. I am unable from memory to state just what the parts are which were my own personal work, but the entire work in every particular was under my direct supervision.

Q. Can you point out any part of it which is your own personal work?

A. Not from memory. If I had with me my original note books I could point out just what work was entirely my own. I can say that the weather conditions — the tide data has been given to me by Mr. Sanbeg. The remaining data has all been carried on either by myself or under my direct supervision.

Q. The second column, date of collection, that was carried on by you under your supervision?

A. Yes, sir.

Q. Were you present when they were collected?

A. NNo, sir, I complied that from the data which I had.

Q. Who furnished the data to you?

A. Mr. Sanbeg.

Q. How does it differ from the direction and the velocity of the wind and the tide so far as the source of your information is concerned?

A. I do not just understand your question.

Q. How does the data that is supposed to be contained in Column 11, the second column headed "Date of Collection" differ, so far as the source from which you received it is concerned, from the next

column, the tide, and the next column the direction of the wind and the velocity of the wind?

A. They coincide as far as the information which I have received goes.

Q. Did you check it up in any way?

A. I have checked it up with Mr. Sanbeg's original notes and found that they agree.

Q. That is all the checking up you did?

A. And then we have the checking from his original
3225 data submitted with the sample, the hour of collection and the date.

Q. I am asking you what you did. What other checking did you do?

A. I have checked the entire remainder of the results outside of what Mr. Sanbeg has given, with the original data obtained, either by myself or by one of my assistants under my direct supervision.

Q. How many of those samples were actually received by you from Mr. Sanbeg on this sheet, I am now showing you the first sheet, the first table?

A. I cannot say from memory. In fact I do not believe it has been recorded whether I received the sample or whether Dr. Pease received the sample.

Q. Well, you have said that you cannot say, have you not, how many you received?

A. Yes.

Mr. Riker: The offer is objected to on the ground that it is not properly proved.

The Commissioner: Note the objection of Counsel for Defendants.

Received and marked Complainants' Exhibit No. 188.

Marked Complainants' Exhibit No. 188.

Direct examination by Mr. O'Sullivan (resumed):

Q. Did you prepare any other reports on these samples Mr. Himebaugh?

A. I have prepared also a tabulation of information given to me by Mr. G. W. Sanbeg, together with the results obtained on the samples submitted by Mr. Sanbeg from beds 924 and other beds designated by the Bureau of Marine Fisheries Conservation Commission, New York State, as lying in Raritan Bay.

Q. The copy of the report that you hand me, Mr. Himebaugh, did you check off the items with the original laboratory notes and with the original data that you received from the collector of the sample?

A. I did.

Mr. O'Sullivan: I offer the report in the matter of the
3226 results of bacteriological examinations of samples of oysters, collected by Mr. G. W. Sanbeg from the waters of oyster beds, designation of the Bureau of Marine Fisheries Conservation

Commission of New York State in Raritan Bay, and delivered by him to this witness. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 189.

Mr. Riker: The same objection as to the last offer.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 189.

Marked Complainants' Exhibit No. 189.

Q. This report purporting to give the results of the bacteriological examinations of the samples of oysters and water collected by Mr. Sanbeg from the waters of oyster bed No. 924, did you prepare that in a way similar to the other reports that have been offered in evidence through you?

A. I did.

Q. And used the same method of checking the items?

A. I did, in each case.

Mr. O'Sullivan: I offer that in evidence and ask that it be marked Complainants' Exhibit No. 190.

Mr. Riker: The same objection as to the last offer.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 190.

Marked Complainants' Exhibit No. 190.

Q. Who directed you to make these tabulations that have been put in evidence through you and are marked as Complainants' Exhibits Nos. 188, 189 and 190?

A. Dr. Pease.

Q. Did you cause the data set forth in Complainants'
3227 Exhibit No. 188 to be plotted in graphic form, together with the other data relative to those oyster samples?

A. At the direction of Dr. Pease I prepared these in the form of a chart, and the chart which I have is a copy of the original.

Q. Did you compare it with the original yourself?

A. I have compared it with the original and have initialed it.

Q. And how do they compare?

A. It compares in all details as far as I was able to see.

Q. It is a blue print?

A. A blue print of a tracing. The original tracing was compared by me with the original data and in every detail it checked. The chart represents in graphic form the number of B. Coli per cubic centimeter in the samples of water delivered to the laboratory by Mr. Sanbeg, together with the number of B. Coli per cubic centimeter in the shell liquor in oysters submitted by Mr. Sanbeg. The temperatures of the water were given to me by Mr. Sanbeg, and I have in addition taken from the monthly summary issued by the Weather Bureau of the United States Department of Agriculture, the observations made in New York City. The mean temperatures for each day I have recorded here, and also the entire rainfall designated in inches, and the snowfall designated in inches, tabulated in accordance with the days of each month.

Q. Did you prepare an original draft, which was the basis of the tracing?

A. I assisted in preparing a portion of this draft. The draft was prepared in my presence and every detail as to the day and readings, which are shown in this chart have been checked by me.

Q. Personally?

A. Personally, and have been found correct.

Mr. O'Sullivan: I offer the graphic chart produced by this witness in evidence as now described by him, and ask that it be marked Complainants' Exhibit No. 191.

3228 Mr. Riker: The offer is objected to for the reasons given on the last offer.

The Commissioner: Note the objection of Counsel for Defendants.

Received and marked Complainants' Exhibit No. 191.

Marked Complainants' Exhibit No. 191.

Q. Can you produce a map or chart showing the actual locations of these oyster beds alluded to?

A. I have here a map which has been given to us by the Sealshipt Oyster System and the location of the beds as designated on this map has been checked by me with an original map in the office of the New York Marine Fisheries, 295 Broadway and the location of beds as designated on this map are the same as far as I am able to tell, as those designated on the original map.

Q. What other data appears on that map besides the locations of the oyster beds?

A. Besides the location of the oyster beds, I have tabulated under the dates on which samples were selected, the weather conditions as given to me by Mr. Sanbeg, together with the bacteriological findings of the samples of oysters submitted by Mr. Sanbeg on the dates given. The figures of the results represent the B. Coli score as given in the standard methods of the American Public Health Association.

Q. And these oyster beds that are located there are in what region, what particular locality?

A. They are here divided into four different groups, one at the mouth of the Great Kills, Bed No. 463. A second group designated here as Group 2, further off from Great Kills, and a third group designated here as Group 1.

Q. What I want to get at, Mr. Himebaugh, is where these groups are located. What vicinity?

A. I think it is indicated on the map itself over there. *A* Raritan Bay.

Q. What particular part of Raritan Bay?

A. Three of the groups near the Great Kills region, and one
3229 of the groups in the Princess Bay region.

Mr. O'Sullivan: I offer this map just described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 192.

Cross-examination by Mr. Riker:

Q. Have you ever been on the ground Mr. Himebaugh?
A. Yes, sir.
Q. Have you located these oyster beds on the ground?
A. No, sir.

Mr. Riker: The offer is objected to on the ground that the paper is not properly proved.
The Commissioner: Note the objection of Counsel for Defendants.
Received and marked Complainants' Exhibit No. 192.
Marked Complainants' Exhibit No. 192.

Mr. O'Sullivan: Your witness.
Mr. Riker: No questions.

HERBERT D. PEASE, a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Dr. Pease, did you hear the last witness testify, Mr. Himebaugh?
A. I did.
Q. I show you Exhibit No. 2, Dr. Pease, and will ask you to compare the table on page 55, with the table on page 56, and state with what results you make the comparison?
A. I have here Complainants' Exhibit No. 2. In the table on Page 55, appear results of examinations of samples collected from points numbered 36, 37, 38, 39, 40, 41, 42, 43, 44 and 45. These
3230 samples of water were collected from the region extending from off Elm Tree Beacon on the south east coast of Staten Island to Lemon Creek on the south coast of the Island, but some distance westerly from Elm Tree Beacon.

In the table on Page 56, there appear the results of examinations of samples of oysters collected from somewhat similar although a smaller number of points extending from off Elm Tree Beacon to Lemon Creek. From the data here presented, it is impossible to state that the samples of water were collected at the same points as the samples of oysters, but for the purposes of the comparison I propose to make, it is not necessary for these points to be identical.

It will be noted from the results of tests for the presence of B. Coli in the samples of water taken from the points I have indicated, that there were no B. Coli in 10 c. c. of samples 36, 37, 38 and 39, and yet examinations of the shell liquor of the oysters collected off Elm Tree Beacon and Great Kills show the presence of B. Coli in, in the first instance, out of six oysters in 1/10 c. c. in one, in 1 c. c. in three, and 10 c. c. inoculations in four. In the latter instance, out of 10 oysters but one showed the presence of B. Coli in 10 c. c. inoculations.

The first point which I desire to call attention to in this comparison is that the shell liquor of the oyters contains a larger number of colon bacilli than in the water samples taken from the different

points. The differences I have called attention to are not as great as are frequently found, but the significance in my opinion, is this, that the oyster in feeding, concentrates the bacteria present in the water in its gill cavities by a process which can be likened to the action of a filter. We expect, therefore, during periods when the oysters are actively feeding, to have much larger numbers of the bacteria which are present in the water, present in the shell liquor of the oysters, than are present in the water in which the
3231 oysters are feeding. I will demonstrate later with other exhibits that these differences are frequently far greater than those observed by the comparison we have made, and I shall show the reasons for these greater variations in the number of colon bacilli present in the shell liquor of the oysters than in the water surrounding these same shell fish.

Mr. Riker: I move to strike out this as being purely speculative, what this witness proposes to show has no bearing on the evidence in this case.

The Commissioner: Note the motion of Counsel for Defendants.

Q. Proceed, Doctor?

A. I desire to call attention in this Exhibit, to the fact that the samples were collected on October 22nd in both instances. I shall show later that the fact that these oysters were collected on that date is of some significance from the bacteriological standpoint.

Before leaving this subject, I desire to call attention to the fact sample 44 in the table on Page 55 is the sample of water collected from Princess Bay and that the results of the examination showed colon bacilli present in 1 and 10 c. c. inoculations. I would compare with this result, the results obtained in the examination of the sample of oysters obtained from Princess Bay on October 22nd, table on page 56, in which colon bacilli were found likewise out of 6 oysters in one instance in 1 c. c. and in two instances in 10 c. c. We find here practically no difference in the results in water system; in fact, if anything, the results of the examination of the six oysters show a smaller number of colon bacilli in oysters than the examination of the sample of water, for it is apparent that at least half of the oysters must have shown no colon bacilli whatever. In view of the presence of colon bacilli in 1. c. c. tests of the water, significance is attached to the failure to find large numbers in the oysters. Again I would call attention to the evidence that examination of
3232 samples of water 45 and 46 on table on page 55 from Lemon Creek showed the presence of colon bacilli in 1/10 c. c. inoculations, as well as in larger amounts, and that the examination of 6 oysters which had been "drunk" in the waters of this creek on the same day, showed only 3 of them to contain colon bacilli in 1/10 c. c. inoculations, although in the use of larger volumes, of 1 c. c. and 10 c. c. practically all of the oysters showed the presence of these organisms. It is, in my opinion, worthy of note that the oysters in this instance were shown to contain smaller numbers of colon bacilli than the sample of water from the general location from which the oysters were taken. I again call attention to the fact

that the oysters were collected during the latter third of the month of October.

Q. One moment, you are talking of what?

A. Exhibit No. 2, the tables on pages 55 and 56.

Mr. Riker: I desire to object to this testimony which is based on Exhibit No. 2 on the ground that Exhibit No. 2 is not properly admitted in this case, not properly proved.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Go ahead?

A. I herewith submit, as a part of my testimony, a schedule of the daily mean temperatures obtained from the Weather Bureau, U. S. Department of Agriculture, for the month of October 1904, together with the mean averages of temperatures for the month of October during the previous forty years.

Q. Where did you obtain this?

A. From the Weather Bureau of the United States Department of Agriculture.

Mr. O'Sullivan: I offer in evidence the mean temperatures taken from the Meterological Summaries issued by the Engineering Bureau of the United States Department of Agriculture, showing the
3233 observations taken in the City of New York of the mean temperature for October 1904; also showing the average mean temperature for the month of October, 1904, and the average mean temperature for the month of October during the past forty years. I offer it in evidence and ask that it be marked Complainants' Exhibit No. 193.

Mr. Riker: It was furnished to you by the Department?

The Witness: Yes.

Mr. Riker: In this form.

The Witness: No.

Mr. Riker: Objected to as not properly proved.

The Commissioner: Note the objection of Counsel for Defendants.

Received and marked Complainants' Exhibit No. 193.

Marked Complainants' Exhibit No. 193.

Q. Have you checked the temperatures as shown in the exhibit thus produced with the original figures furnished you by the Bureau that you have stated you have obtained it from?

A. The original record was not available at the time, and these temperatures I obtained from the New York office of the Weather Bureau over the telephone, and I have had no opportunity as yet to check them.

Q. You may proceed, Doctor?

A. It will be noted that the mean temperatures for that month were generally under 60° and on the 17th, 13th, 23rd, 24th, 27th, 28th, 29th, 30th and 31st, they were under 50° F. The average mean temperature for the month was 53.3° F., while the temperature

for 40 years for the same month was 55.6° F. That temperature has a very pronounced effect upon the physiology and activity of oysters, and that other things being equal, a period of low temperature, such as occurred in the month of October, 1904, from the first almost continuously until the 18th, would tend to inhibit
3234 the feeding of oysters and thus reduce the tendency to concentration of bacteria in the gill cavities of the oysters. The conclusions which I present from a study of these two tables are that the results of the examinations of the oysters collected from off Elm Tree Beacon, Great Kills and Princess Bay as shown on table on page 56 of Exhibit No. 2, show smaller numbers of Bacillus coli than would be expected from the results of the examinations of samples of water from similar locations, or from the results of examinations of oysters taken from these locations during the warmer periods of the year.

Q. Now, Dr. Pease, I hand you Complainants' Exhibit No. 182 and direct your attention to page 892 of that exhibit, also to Complainants' Exhibit No. 181.

At 1 P. M. adjourned for noon recess until 2 o'clock P. M.

3235 CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, Sept. 17, 1912—2 o'clock p. m.

HERBERT D. PEASE a witness called on behalf of Complainants, recalled for further examination, testified as follows:

Direct examination by Mr. O'Sullivan (resumed):

Q. Now, Dr. Pease, I hand you Complainants' Exhibit No. 182, and direct your attention to page 892 of that exhibit, also to Complainants' Exhibit No. 181, and ask you to compare the results of the examinations of samples of water with those of the examinations of samples of oysters for the same, or approximately the same stations and give the results obtained from the examinations of samples of both water and oysters from the respective districts from which the samples were obtained.

Mr. Riker: The question is objected to on the ground that the two exhibits named have not been properly proved and cannot be used as a basis of testimony in this case.

The Commissioner: Note the objection of Counsel for Defendants.

A. I present as a portion of my testimony a tabulation showing a comparison of results of tests for B. Coli in samples of water with results obtained from the examination of the shell liquor of oysters obtained from sampling stations in close proximity, the results in both instances having been taken from the table on Page 892 of Exhibit 182. This tabulation was prepared by placing under separate titles the results of the examinations of samples of water and of oysters obtained from locations approximately in the same general districts which are indicated in this tabulation as
3236 "Inside Great Kills," "Off Great Kills Point," "South from Great Kills Point," "South-west of Great Kills," "Off Princess

Bay," and the "Beds East of Tottenville."

Q. Did you prepare this tabulation yourself, Doctor?

A. I did.

Q. And verified the various figures of items in it?

A. I have.

Mr. O'Sullivan: I offer this tabulation in evidence and ask that it be marked Complainants' Exhibit No. 194.

Cross-examination by Mr. Riker:

Q. What is this tabulation based on?

A. The results as reported on page 892, and compared with the sampling stations with the same numbers on Exhibit No. 181.

Q. What part did you have in preparing either one of the series of data upon which this tabulation is based?

A. This exhibit No. 182 and 181?

Q. Yes.

A. The work done and here recorded was reported to me, and submitted by me to the State Commissioner of Health.

Q. Was reported to you, not made by you?

A. Reported to me by Mr. Wachter who has already testified.

Q. And No. 181?

A. This number 181, this chart or map was also given to me by those who were working under my supervision in 1908 in the State Department of Health and was transmitted by me to the State Commissioner of Health as part of this report.

Q. None of this was done by you as original work, was it?

A. No.

Mr. Riker: The offer is objected to for the same reasons that the exhibits themselves were objected to, that is No. 182 and 181.

The Witness: May I ask a question. When you asked me if any of the work was done, did you mean the actual physical
3237 work, not the drawing of conclusions and the mental application in the formation of this report, that was mine absolutely.

Mr. Riker: I understand. The same objection.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 194.

Marked Complainants' Exhibit No. 194.

Direct examination by Mr. O'Sullivan (resumed):

Q. Proceed.

A. There appears in the third column of Exhibit No. 194 a heading "Approximate B. Coli score." The method of representing the results of tests of the shell water of oysters for the determination of numbers of B. Coli present in them, as a score, is an arbitrary procedure recommended by The Committee on Standard Methods of Shell-fish Examination of the Laboratory Section of the American Public Health Association. I herewith present as a part of my testimony, a copy of the preliminary report of this Committee read be-

fore the Laboratory Section of the American Public Health Association in Milwaukee, in September, 1910. The determination of these scores requires that the examinations of the oysters be conducted in a particular manner, and it has not been possible to interpret the results reported in the table on Page 892 of Exhibit 182 by accurate B. coli scores, but approximations have been determined and here inserted, purely for the purpose of rendering the report of the results of tests for B. Coli more readily comparable. However, the detailed results as they appear in Exhibit No. 182 are likewise given. Considering the results of the tests on water and oysters for each particular group or district, it will be noted that in none of the tests of the samples of water, were B. Coli present, whereas in the tests of similar quantities of the shell liquor of oysters, frequent positive results were obtained. A similar result is to be noted in the comparing of the determinations on samples of water and of
3238 the shell liquor of the oysters from the samples collected off Great Kills. The results of the examinations of five samples of water from the district "South of Great Kills Point" showed the presence of colon bacilli in volumes of 1 c. c. or smaller, in but one instance. Here, again, the results of examinations of the shell liquor of oysters showed much more frequent positive results in tests of 1/10 c. c., and in one instance, in 1/100 of a c. c. test. The results of the examinations of two samples of water from the points "Southwest of Great Kills" were positive in 1 c. c. test in both instances, but here again the oysters showed much larger numbers of B. Coli in the shell liquor. The comparison of the results of examinations of water and of oysters collected from points "Off Princess Bay" and from "Beds East of Tottenville" showed these same general results. In fact, in no instance, in the results of examinations as they appear in the table on Page 892, Exhibit 182 do those of the shell liquor of oysters fail to indicate the presence of larger numbers of colon bacilli than are indicated as present in the samples of water collected from points in these same approximate locations.

In comparing the results of examinations of water and of oysters, collected from points in the groups indicated in this table, page 892, Exhibit 182 it can be said that there appears, in general, to be no definitely greater pollution in any of these sections greater than in any of the others. In other words, the distribution of colon bacilli in the waters and in the oysters from which samples were taken, appears to have certain degree of uniformity. The variations to be noted are but rarely pronounced. Samples from 3 locations gave results indicative of the presence of larger numbers of colon bacilli than were present in sample in other locations. The first of these is oyster sampling station bearing the numbers 63.2-162.2. It
3239 should be noted, however, that the oysters from oyster sampling station bearing the number 62.2-161.2, which is in close proximity, as shown by the map, Exhibit 181, while showing large numbers of colon bacilli, did not show as large a number as the first station mentioned. I conclude that the results obtained in the examination of a sample from the first station mentioned are either due to some special local condition at that point, or that the re-

sults were due to unusual conditions present at the time the samples were collected. It is well known that samples from channels or deep depressions in oyster grounds which are washed by waters containing sewage pollution, will show relatively larger numbers of colon bacilli than will samples collected from adjoining flats or nearby points.

The second and third locations to show unusual numbers of B. coli in the shell liquor of oysters, p. 892, Exhibit 182, are 103.2-.65.2 and 104.2-166-2 beds off Princess Bay and East of Tottenville. The results obtained from the examinations of the samples from these two locations can be attributed to the pollution of that part of Raritan Bay by the sewage from the munipalities described in Exhibit 182, Page- 890, 891, the same being a part of the sanitary inspection made under my general direction by the Division of Sanitary Engineering of the New York State Department of Health in 1908.

Q. You have already testified to your method of procedure in these examinations of water and oyster samples. Did you make any sanitary inspections of the surroundings of the oyster beds on the south shore of Staten Island?

A. One such sanitary inspection was made at my direction and under my supervision by one of my assistants and reported to me under date of Friday, July 1st, 1910. This report also contains the results of the inspection of records of the Metropolitan Sewerage Commission as made by this assistant, at any request, and with the permission of the President of the Commission. This report
3240 of region around about these oysters is presented as a part of my testimony.

Q. Was this an original report?

A. This assistant made weekly reports, but this inspection was the work of that week.

Q. Who were the reports made to?

A. The reports were made to me.

Mr. O'Sullivan: I offer the report produced by this witness and described by him in evidence, being the weekly report of Dr. H. D. Pease, of the Lederle Laboratories on sanitary inspection of the south shore of Staten Island, and ask that it be marked Complainants' Exhibit No. 195.

Cross-examination by Mr. Riker:

Q. Who made this report?

A. Payn B. Barsons.

Q. Where is he?

A. Now?

Q. Is he alive?

A. Yes, as far as I know. He is on the staff of the Metropolitan Sewerage Commission. At that time he was assistant in the Bacteriological Department of the Lederle Laboratories, under my supervision and direction.

Q. Do you know whether he has already been sworn in this case?

A. I cannot say of my own definite knowledge, but I have heard that he was.

Q. Is this report as he presented it to you?

A. Exactly.

Mr. Riker: The report is objected to on the ground that the report, if evidential at all, should be proved by the person who made it, it appearing that he is still in the Land of the Living and can be produced.

The Commissioner: Note the objection of Counsel for defendants. Received and marked Complainants' Exhibit No. 195.

Marked Complainants' Exhibit No. 195.

Direct examination by Mr. O'Sullivan (resumed):

Q. Dr. Pease, I hand you Exhibit- Nos. 188, 189, 190, 191
3241 and 192 and ask you to state what you did in relation to those exhibits prior to today, when they were offered as exhibits?

A. All of the original records giving the information as to the source of the samples and by whom collected, and all of the cards showing the results of the examinations, have been examined by me on several occasions, and the plans for the presentation of this data and the results of the examinations were made by me and the Exhibits were prepared under my direction.

The plans for the preparation of these exhibits were formulated by me and also issued by me to my Assistants who compiled the results of the examinations and the data in our original records in these forms. I have compared the results of a large number of the data charted in these exhibits with the original records. The original records have been examined by me on a large number of occasions in connection with the making of reports of examinations and expressions of opinion to my clients as to the sanitary condition of the oyster grounds from which the samples were examined and the data here charted.

Q. Directing your particular attention to Exhibit No. 191, for B. Coli in the samples of water with the results from the test I ask you what relation exists between the results of the tests applied for B. Coli in the shell fish liquor of oysters?

Mr. Riker: The question is objected to on the ground that it is based on an exhibit which has not been properly proved in the cause.

The Commissioner: Note the objection of Counsel for defendants.

A. A comparison of the results of B. Coli tests on samples of water collected from oyster bed No. 490, Exhibit No. 191 with those made on the shell liquor of oysters collected from the same bed show that with the exception of the period beginning early in November 1811 and extending to the first of May, 1912, in no instance were
larger numbers of B. Coli found in one C. C. samples of the
3242 water than were found in similar quantities of the shell liquor of the oysters. This preponderance of positive results of tests for B. Coli in the shell liquor of oysters over the waters surrounding these shellfish, indicates an active condition on the part of the

physiology of the oyster. In the period that I have mentioned, early in November 1911, and extending to May 1912, the results already mentioned do not hold good. The results of the examination of samples of water and samples of oysters as here shown demonstrate that there were larger numbers of B. Coli in the water during the period I have mentioned than in the shell liquor of the oysters. This demonstrates an inactive condition on the part of the oysters, and is due, in my opinion, to the low temperature of the waters in which the oysters are located. This inactive condition of the oysters due to the low temperature of the water I have designated as a hibernation of the oyster. Until I applied this term to this condition of oysters, in May 1910, the fact that oysters hibernated was not known.

I desire to call attention to the fact that the curve of mean temperatures during October, 1911 as shown by the exhibit now under consideration shows for the first twenty two days much higher records than appear in the record submitted by me as Exhibit 193 which shows the daily mean temperatures for October 1904. The results of the tests for B. Coli in water and oysters in the samples collected in October 1911 show upon the chart Exhibit 191 that while the numbers of B. Coli in the shell liquor of the oysters was somewhat larger than the numbers in the samples of water, nevertheless, they tend to approximate each other in October. In the latter part of November, 1911, the results clearly show larger numbers of B. Coli in one c. c. samples of the water than in similar quantities of the shell liquor of the oysters. Given colder weather in October,
3243 1911, the numbers of B. Coli in the water would have been equal to the numbers of B. Coli in the shell liquor of the oysters and the comparison between the numbers of B. Coli in oysters and water would have been identical or more closely resembling those noted in the table on Page 55 of Complainants' Exhibit No. 2.

I desire to point out the following facts demonstrated in the chart which constitutes Exhibit No. 191. First, it should be noted that unusually large numbers of B. coli in the shell liquor of oysters are to be noted in the months of September, 1911, June, July and August 1912. I further point out that the presence of more than 7 B. coli per c. c. in the shell liquor of oysters occurs only in the months of September and October, 1911, and May, June, July and August, 1912. With the exception of the period between December 15th, 1911 and March 28th, 1912, during which no samples of oysters or of water were collected, there appear to be no instances in which samples of oysters show as large a number as 7 B. coli per c. c. of shell liquor.

I direct attention be especially called to the repeated drop in the numbers of B. coli in the shell liquor of oysters in the latter part of October, and the first part of November, 1911, and to the fact that so far as the examinations were made, smaller numbers of colon bacilli per c. c. of shell liquor continued until the following May. The results here shown are not in the least exceptional.

Instances could be multiplied where similar drop took place at approximately the same time in the year 1911 and a similar rise

which took place in the year 1912 in the month of May. In fact the instances in which the drop in the numbers of colon bacilli per c. c. of shell liquor of oysters occurred as the result of the examination of samples made under my direction in the Fall of 1910,

that I felt the necessity of studying the cause of this fall,
3244 and finally came to the conclusion that this repeated decrease in the numbers of colon bacilla in oysters which were taken from waters more or less polluted with sewage was due to a decided biological change in the oysters, and was probably due to the development of a condition of hibernation. The fact that oysters hibernated was not known prior to this time, at least if the phenomenon had been observed by scientists no mention had been made of the same in the literature on the biology of oysters. On May 17th, 1911, at the meeting of The Oyster Growers and Dealers Association of North America I gave expression to my opinion that oysters entered into a true state of hibernation with the advent of a low temperature of the water surrounding them, and that this hibernation continued until the advent of a decidedly increased temperature in the Spring. The study shown in the chart Exhibit No. 191 and made for the purpose of not only adding further confirmation to the observations which had already been made, and in support of the statements which had been previously published, but for the purpose of obtaining more accurate information as to the temperatures of the atmosphere which would tend to bring on hibernation, but also to determine the temperatures of the water which would tend to prolong the period of hibernation or which would cause a cessation of the same. From a study of the details as shown by the data plotted on the chart constituting Exhibit No. 191, I draw the conclusion that *when* the onset of decidedly cold weather in the Fall months, either in the latter part of October or the first or middle of November, with a consequent fall in the temperature of the water in which oysters are located, that the oysters pass into a stage of complete hibernation, which persists as long as the temperature of the water is below 42° F., but with the increase of the temperature above this point, there is a gradual

cessation of hibernation, although there is no evidence that
3245 the oysters resume the activity which they displayed in the previous summer and fall, until the temperature of the water reaches 60° F. In the period in the Spring months, when the temperature of the water is irregularly increasing from 42° F. to 60° F. shown in Exhibit 191, the results of the examinations of the samples of oysters do not show the presence of as large numbers of colon bacilli as did the examination of samples in the month of October when the temperatures of the atmosphere were approximately the same. With the advent, however, of temperatures continuously over 50° F. the results of the examinations of samples of shell liquor of oysters approximate those obtained by the examination of samples in the latter part of September and the first of October, when the temperatures were approximately the same. I draw the conclusion from these facts that with the reduction of temperature in the Fall, the oyster passes first from a stage of a very

active feeding into one of comparative physical inactivity, although until the temperature passes decidedly below 45° F. the oysters do not pass into a state of complete hibernation. In the Spring, with the advent of warmer weather, and an increase in temperature in the water, the oysters proceed more slowly to revive from the state of true hibernation, but do not begin actively feeding until the water has reached 60° F. and remains there. These facts have a most important bearing on the significance of the results of the examinations of samples of oysters for the presence of numbers of colon bacilli in the shell fish. The results of such examinations have been accepted as indicative of the sanitary conditions of oyster grounds, and all the fitness of the oysters for food purposes. I desire to submit the results of recent tests made by me as to the effect of a temperature of 36 degrees upon the exclusion from a sample of oysters in a solution of fushsine of the coloring matter of
3246 that solution from the interior of the oysters. In this report appears the interpretation that as the particles of this dye are indefinitely smaller than the bodies of bacteria, it is a warranted conclusion that such a complete closure of the shell as was here demonstrated, would mean the total exclusion of bacteria from the body of the oyster or its cavities. I submitted a report of experiments made by me under the title "Testing Oysters for the effect of Temperature upon the Active or Aducta Muscle."

Q. Prepared by whom?

A. This experiment was done by me, made by me.

Q. Personally?

A. Yes.

Mr. O'Sullivan: I offer that in evidence and ask that it be marked Complainants' Exhibit No. 196 in evidence.

Mr. Riker: The offer is objected to on the ground that the issue is not whether or not the annual processes of the oyster are properly called hibernation or not, but whether or not the proposed discharge of the Passaic Valley Trunk Sewer will create a nuisance in New York Harbor.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 196.

Marked Complainants' Exhibit No. 196.

Q. Proceed, Doctor, please?

A. I conclude from an examination of Exhibit No. 191 that the oysters grown in the waters of Lower New York Bay in the vicinity of Great Kills undergo complete hibernation beginning in the Fall months and extending until the Spring, and that such complete hibernation excludes the entrance of any sewage pol-
3247 lutted materials even the sewage bacteria from the body or tissues of the oyster.

There can be therefore no menace to health in the consumption of the oysters obtained from these waters during the period of complete hibernation, even if the oysters are eaten in the raw state. However, there is another factor which develops in the oysters in this location at the time of the development of hibernation which practically excludes them from sale upon the market. I refer to

the development of the so-called greening of oysters, which consists in the appearance of a bright green color upon the gills and in the vessels of the body of the oyster.

Q. Dr. Pease, in the course of your investigations and laboratory experiments on the subjects that you have just testified to in relation to oysters have you investigated the subject of the green coloration of oysters?

A. I have been investigating the subject of the green coloration of oysters during the past two years. I have read the literature on the subject thoroughly. It appears from my studies of the literature and from the personal investigations which I have made, that the development of the green color of oysters is an action which occurs during the late fall months. It apparently begins at the time hibernation starts. An exact chronological connection between greening and hibernation has not yet been made out by me, but it is certain that the time of onset of both is approximately the same. The green in oysters appears to persist during the hibernating period, and even for much longer periods. Oysters which have been grown in waters where greening regularly takes place in the fall of every year, have been transplanted to remote oyster grounds in other states where greening has never been known to take place, and yet in the transplanted oysters there have been some which have shown traces of green color for at least two years. As a
3248 general rule, however, the green color leaves the oysters during the succeeding summer after the onset of the greening the previous fall. In the literature there have been numerous descriptions of the green color of oysters being due to the presence of certain low forms of vegetable or animal life, having a green coloration in the food upon which the oysters have been feeding. It is quite possible that this is the case, but I have personally made no observations of green oysters of this type, if they exist. The green oysters investigated by me have shown an accumulation of blood cells on the surface of the gills. These blood cells contain fine, round granules of green color in varying numbers. When the blood cell breaks up by handling, these granules appear in the surrounding liquor. The blood cells in the blood vessels of the oyster likewise contain these green granules. It is quite possible that these blood cells have been mistaken by some observers for low forms of animal or vegetable organisms. In the oysters I have investigated, these cells are clearly demonstrable as blood cells. I have examined a large number of green oysters from Bed 490, off Great Kills, these oysters having been brought to me by Mr. Sanbeg. I desire to submit, as part of my testimony, a report on the investigation of samples of oysters which have been submitted to me, samples were represented as coming from oyster grounds in various parts of this country, Canada and England. The examinations of these oysters were made for the determination of the amount of copper in them.

Q. What part did you direct done in the subject matter of this report, Dr. Pease?

A. I examined a considerable number of the oysters for the presence of the green color. The oysters were then transmitted by

me to the chemist of the Lederle Laboratories, who made examinations as to the amount of copper present in the samples submitted.

3249 Q. Under your direction?

A. Under my direction.

Mr. O'Sullivan: I offer the report just described by this witness in evidence and ask that it be marked Complainants' Exhibit No. 197 in evidence.

Mr. Riker: Has the presence of copper any relation to the pollution of sewage pollution?

The Witness: Not that I have as yet determined.

Mr. Riker: The offer is objected to as being immaterial and irrelevant to the issues in this case.

The Commissioner: Note the objection of Counsel for Defendants. Received and marked Complainants' Exhibit No. 197.

Marked Complainants' Exhibit No. 197.

Q. Dr. Pease is this green colored oyster often mistaken for a polluted oyster?

A. Very frequently.

Q. And is objectionable in the oyster trade, is it?

A. Very objectionable.

Q. What inferences do you draw, Dr. Pease, from this report that has now been marked Complainants' Exhibit No. 197?

Mr. Riker: The question is objected to as irrelevant and immaterial and incompetent, dealing with a matter outside the issues in this case.

The Commissioner: Note the objection of Counsel for Defendants.

A. The conclusions which I wish to make from a study of this report are as follows: That oysters containing green coloration show a greater amount of copper than normal colored oysters obtained from the same location:—that normal colored oysters are frequently obtained which show much larger amounts of copper than green oysters from other locations. There is no direct relation between amounts of copper present and green color, other than stated

3250 in my first conclusion. Copper appears to be present in oysters without producing green color, for in fact, all oysters examined under my direction have contained traces of copper. The presence of the green color in certain oysters appears, therefore, to be associated with the presence of copper in some unusual form or combination. It is well known that copper can exist in combination with cellulose, which is the common ingredient in vegetable organic matter, but this combination takes place most readily when the copper is in the form of cuprammonium. The presence of copper and free ammonia with cellulose can result in the combination of the same, even at low temperatures. The cuprammonium cellulose, is however, a loose combination between the respective chemical elements and can be readily broken up by great dilution. If such a combination gained access to the food of oysters and was taken in by them the organic elements would doubtless be digested

by the oyster, leaving the metallic compound not absorbed, or, if they were, absorbed into the digestive tract of the oyster, it would be necessary for the oyster to eliminate the same. The eliminating apparatus of the oyster is not thoroughly understood. It is known, however, that the oyster has no kidney and it is altogether probable that the breathing apparatus of the oyster serves the purpose of a kidney. In any event, we find the blood cells of the oyster carrying the green pigment, which is, in my opinion, basic copper chloride, and it is further my opinion that the oysters are attempting to eliminate this metalic element from their tissues when the larger number of blood cells containing this pigment are found upon the surface of the gills of the oysters. Another possible interpretation, but one which does not appeal to me strongly is that the green pigment is present upon the surface of the gills of the oysters and that the blood cells have passed out of the blood vessels and have en-
3251 gulfed the same, a certain number of them passed back into the blood vessels and there attempted to destroy this pigment. In either case, it must be assumed that the pigment appears in the oysters as the result of the feeding or drinking of the shellfish, upon food containing copper in combination with it, for if the copper was merely held in solution or in suspension in the sea water, it would undoubtedly pass through the gill cavities without exerting any effect upon the same, in the same way that sand and particles of inert substances pass through these same cavities. I have already stated that copper, free ammonia and cellulose, when brought in intimate contact, can result in the formation of a double celloid salt of cellulose at temperatures of sea-water in the summer or fall seasons. The conditions, therefore, under which this combination takes place are those which very commonly exist in the late summer and fall on some oyster grounds. In oyster grounds which are polluted with sewage, there are to be found in all instances varying amounts of free ammonia. When, however, sewage deposits exist in considerable amounts on the bottoms of tidal waters, these deposits commonly undergo anaerobic decomposition with the production of free ammonia and other products of decomposition. The ammonia produced by such anærobic decomposition would be readily available for combination with all forms of organic matter and copper for the production of couprammonium cellulose or copper protoids. I desire to state here that all sea water contains copper in varying amounts in different locations. If this combination took place and the same was taken up by the oysters lying on the surfaces of such deposits or in close proximity to the same, the conditions would be ideal for the production of the green color in the oysters. However, such conditions of anaerobic decomposition are undoubtedly present in the warmer seasons of the year before the de-
3252 velopment of green color is generally noted, and it is altogether possible for oysters to consume during these months, particularly August and September, these copper-containing foods without the appearance of green color. For example, it would be entirely possible for an oyster in the state of full physiological activity, to thoroughly digest the organic elements of such food and

excrete the metallic compounds as well. When, however, the sea water becomes colder in the later fall months, the activity of the oyster is restricted, and while it might be entirely possible for the oyster to digest the readily assimilible organic elements of copper-containing foods, it might experience considerable difficulty in excreting copper compounds which had been associated with such foods. The result in such an instance, would be accumulation of such copper compounds and the development of the green color would be the logical result. I conclude the presence of the green color of oysters is due to the consumption by the oyster of organic food substances containing in loose combination, copper compounds, and that at the time of the development of the green color, the oyster, while able to digest and assimilate the organic elements in these foods, is unable to sufficiently excrete the copper compounds, and that the same accumulate in the oyster and that the green color of the gills is due to the effort on the part of the oyster to eliminate these copper compounds through the action of the extrusion of large numbers of blood cells, containing the copper pigments, out into the gill covities. It is further my opinion that these copper cellulose and proteid compounds are formed as the result of anaerobic decomposition of organic materials, either on or in location adjacent to such oyster beds. Whether or not the copper must be present in the sea water or in the sludge deposits on tidal bottoms in some particular form other than as the copper may exist
3253 normally in sea water, has not as yet been determined by me. It is entirely possible that the copper exists in sea water or in such sludge deposits in some special form and that it gains access to these deposits from trade wastes which may form a constituent part of the sewage from some municipalities or industrial establishments, but as I have already stated, I have not as yet been able to determine that the copper must exist in these special forms as trade wastes.

Q. Dr. Pease, does the question of the pollution of oysters, so far as the oysters of New York Bay are concerned, relate to the use of these oysters during the non-hibernating period of the year?

A. It does.

Q. Now, what significance have the results of your examinations of the samples of oysters as contained in the exhibits that have just been submitted in relation to the use of oysters for food in the raw state?

A. I have already expressed the opinion that the results of the examinations of samples of oysters as they appear in the table on Page 55, Complainants' Exhibit No. 2, show that the oysters were in a condition of complete inactivity and that the numbers of B. coli were correspondingly low. As *this was* the only availiable results of examinations made prior to 1908, a comparison of these with those made in 1908, 1910, 1911 and 1912, would hardly be warranted, unless the comparisons were confined to months showing similar conditions of temperature.

I have already presented the results of the examinations of oysters which were made under my direction in the months of August and

September, 1908, showing the results of the examinations of oysters collected from certain beds in the same general geographical group which have been presented as exhibits.

3254 Q. Dr. Pease, directing your attention to Exhibit No. 192, I ask you what relation exists between the number of colon bacilli found at present during corresponding periods in the beds grouped under the four heads as shown by the different colors in this exhibit?

A. Excluding the results which appear in exhibit No. 192, which were obtained from samples collected during the hibernating period, namely, those collected after November 4th, 1911, it can be said that on the whole, the results of examinations in the months of August and September, 1910, and in the same months in 1911, and those in 1912 during the same period, that during the last three years somewhat higher B. coli scores, or numbers of B. coli, have been found in the shell liquor of oysters than were determined to be present in the examinations made in 1908. However, these increases are in part due to particularly high scores obtained in one or two instances, whereas the average of the scores made after eliminating these particular instances, show approximately the same numbers of colon bacilli as were found in 1908. Whether the greater frequency of these unusually high scores in the last three years indicate a greater degree of sewage pollution of the waters of these regions, cannot be stated positively, but it is suggested.

Continuing my discussion of Exhibit No. 192, I would say that in general the results are similar to those already discussed in the consideration of the investigation made in 1908. There appears to be no one of these groups which shows constantly a larger number of colon bacilli in the shell liquor of the oysters than are found in the same material from samples from the other groups of beds. In fact, I desire to express the opinion that the distribution of such pollution as exists in the waters of the oyster beds of this region, as shown by the results of the examination of the

3255 oysters during the non-hibernating period of the years 1908, 1910, 1911, appears to be remarkably uniform. For this reason, it is warranted to assume that such pollution as has gained access to these waters is distributed in them with a reasonable degree of uniformity. This, in turn, warrants the conclusion that the polluted materials do not gain direct access to these waters from any particular sources of minor pollution, but that there is some large source of pollution which permits of an even distribution of the polluting materials in the waters over this extensive area.

In my studies on the sanitary conditions of oysters in other large bodies of water, such uniformity of distribution of pollution has not been noted. Since my investigations of all kinds in 1908, I am of the opinion that the main source of the pollution of the oyster beds which are off Great Kills and in the vicinity of the the oyster beds as shown in Exhibit 192 in which there appear the arrangement of some of these beds in three groups, come into the waters of the lower Bay through the Narrows, and that this pollu-

tion finds its way, in large part at least, in an indirect manner to the oyster beds in question.

I have frequently expressed the opinion that the oyster beds off Great Kills in the lower New York Bay were safe for consumption even in the raw state, when removed from the beds during the non-hibernating period of the year; but that if any substantial increase in the pollution of the waters passing over these beds should occur, that the oysters in the non-hibernating period of the year would then contain such numbers of colon bacilli as would make their shipment in Interstate Commerce illegal on account of the action which has been taken in the past by the officials of the U. S. Government connected with the enforcement of the Pure Food Law.

3256 Q. What is the effect of sewage pollution on oysters in your experience?

A. The effect of sewage pollution on oysters is to increase the numbers of B. coli to be found in the shell fish liquor of the oyster during the non-hibernating period of the year.

Q. And as to oysters as a food supply, what effect does it have?

A. You mean sewage pollution?

Q. Yes.

A. Sewage pollution of oysters, if carried to a great extent, or if the amount of pollution is great, or if the amount of pollution is small, but the pollution is very direct in its character, tends to make oysters unfit for consumption in the raw state during the non-hibernating period of the year.

Will screening and sedimentation remove the unjurious elements from the sewage so that the oysters will not be affected thereby?

A. I do not desire to qualify as a sanitary expert, but as B.coli have been found by me in a large number of instances in sewage, which has been treated in this manner, the effluent from plants so treating the sewage *have* polluted the waters around oyster beds, the B.coli having been found in large numbers in such oysters.

Q. From your knowledge and experience of the conditions of the oyster beds in the Lower Bay, would further pollution tend to destroy these oyster beds, if appearing in increased quantity?

A. An increased pollution of the waters of Great Kills with the appearance of persistently larger numbers of B.coli in the oysters removed from those beds, would lead me to advise my clients who control those beds to abandon the use of the same for marketing oysters.

Mr. O'Sullivan: Your witness, Mr. Riker.

3257 Cross-examination by Mr. Riker:

Q. What stage of pollution in your judgment renders the oyster unfit for human consumption in the raw state?

A. That is impossible to answer as a general matter. Each instance has to be considered by itself.

Q. Does the presence of one typhoid germ in an oyster bed suffice to render them unfit for human consumption?

A. The presence of one typhoid bacillus in the oyster would indi-

cate the possibility of much larger numbers of typhoid bacilli being in the adjoining oysters.

Q. I was talking of that one oyster, if there was one typhoid bacillus in that oyster, in your judgment is it safe to eat, even in the raw state?

A. No.

Q. Have you determined in your tests the presence of the typhoid bacillus as distinguished from the colon bacillus?

A. I have not.

Q. Who is it that you are advising as you clients?

A. I have several clients who own and control beds in that region.

Q. Are they raising and marketing oysters from those beds?

A. They are.

Q. That is their business?

A. That is.

Q. And you have advised them that while the oysters are approaching the point where they should not be sold, they may still go on and sell them?

A. I have.

Mr. Riker: That is all.

Mr. O'Sullivan: That is all.

AZEL F. MERRELL a witness called on behalf of Complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Your full name?

A. Azel F. Merrell.

3258 Q. Where do you reside?

A. I live at Mariners Harbor, Staten Island.

Q. What business are you in, Mr. Merrell?

A. Wholesale oyster business.

Q. How long have you been in the business?

A. All my life.

Q. Where did you begin in the oyster business?

A. I began first to cull seed oysters.

Q. Where?

A. Staten Island Sound.

Q. Known now as the Arthur Kill?

A. Yes, sir.

Q. Just tell what you know about the oyster business?

A. Why, at that time the northern part of Staten Island and the western part was a gold mine for the people who lived on that side of the Island. They made their living by catching seed oysters and those far enough advanced, they took them to Princess Bay and planted them. At the end of three or four years, as the case might be, they began to take these oysters up from Princess Bay and sold them, marketed them. Some, who were not so fortunate, sold them, sold all they caught to the dealers who did business and planted them for their own account.

Mr. Riker: I shall have to move to strike this testimony out as entirely incompetent. It is not introductory, and it is cumbering the record with matter that is incompetent and irrelevant.

The Commissioner: Note the motion of Counsel for Defendants.

Q. Are you connected with any large body of oyster growers?

A. Yes, I have been President of the Oyster Growers and Dealers Association of North America.

Q. How long have you said that you were in the oyster business on the Staten Island shore?

A. All my life.

Q. Give us some idea in years, Mr. Merrell?

3259 A. Well, I began possibly at the age of 15 or 16 years.

Q. 20 years, 30 years?

A. Yes, sir, more than that.

Q. Now, do you know anything about the oyster beds in the neighborhood of Princess Bay?

A. Yes, we have considerable beds down there.

Q. I show you Complainants' Exhibit No. 181. When first you went into the oyster business, Mr. Merrell where were the great seed oyster areas?

A. All along this Kill van Kull and on the north side of Staten Island, and down the Arthur Kill. We called it then the Staten Island Sound. They were very prolific natural oyster beds. There was nothing taken from those waters for food—it was all seed land.

Q. Were there any beds in the Upper New York Bay when you first went into the business?

A. Yes, sir.

Q. Extensive beds?

A. Quite extensive, yes, sir.

Q. Were they marketed?

A. Yes, they were taken directly from those beds and sold in the markets of New York.

Q. Where do the oyster beds lie. Will you indicate on Complainants' Exhibit No. 181 the areas covered by the oyster beds?

A. Along the shore on this map, New York Bay, but the food beds were down here in Raritan Bay, beginning at Tottenville and going down as far perhaps as nearly to Great Kills Bar. The Bar at that time was not used. Along to the west of that Bar.

Q. What oyster grounds are now left on the Staten Island shore?

A. Very few, just a little trace of lanes right here from the east of the old orchard shoal buoy to the Elm Tree light and from there a strip out towards the ocean.

Q. Are there any west of that line?

A. What was once the best of the oyster lanes was west of that point.

Q. What condition are these earlier oyster lanes in now?

3260 A. They do not use them now at all.

Q. Are they abandoned?

A. They have been abandoned, yes, sir.

Q. Do you mean the ones east or the ones west?

A. I meant the ones west, between the mouth of the Arthur Kills and Great Kills Bar, all along the south shore of Staten Island.

Q. Why were they abandoned?

A. Because they were told that the oysters produced by them were not fit for food and the oyster men themselves were not anxious to sell something that was not good and they had to abandon them. They could not use the ground for the raising of oysters.

Q. Where did the sewage come from that destroyed the usefulness of these beds?

A. The sewage that destroyed these beds came down the Arthur Kill and the Raritan River.

Q. Did you see any indications of that sewage other than the destruction of these oyster beds?

A. The only other indication I saw was on the sides of vessels or boats.

Q. What would it do to the boats?

A. Any light colored paint it would discolor it over night. If it was damp, foggy weather, in the morning—the gases rising would discolor the paint.

Q. Was that in the Arthur Kill?

A. Yes, in the Arthur Kill and the upper part of the Lower Bay.

Q. What discoloration would take place, would it be black?

A. Yes, a very dark color, dark green.

Q. Would it be any other color beside dark green?

A. No, just a dark sickening green color.

Q. A very dark green?

A. Very dark.

Q. Was it almost black?

A. Yes, quite black.

Q. Did you see any other indications of the sewage there on piles or spiles or posts?

2261 A. Yes, all along the western shore of Staten Island, there is marsh land, more or less, and when the tide rises and falls and leaves a deposit on the edge of the meadows, on this salt grass, it destroys it completely. It is so dark that anyone who goes down there can see the discoloration, and on the side of the meadows, the banks, it is slimy and disgusting.

Q. Have the number of men engaged in the oyster industry along Staten Island shore decreased?

A. Oh, indeed they have almost all left the business and gone into something else. There are very few of the older oyster men who used to make their living from seed bed and oysters, they have gone somewhere else.

Q. Were there many of them?

A. Why, yes, sir, almost the entire population of the west side of Staten Island was composed of oyster men who made their living entirely by working on seed lands or being employed by others who hired them for work in the Lower Bay.

Q. Were there thousands of them?

A. Yes, sir.

Q. Give me some idea of the number?

A. I should say that a very conservative estimate of that number would be five thousand.

Q. They have disappeared from the business.

Mr. Riker: When is this witness talking of now?

The Witness: Of a period of about twenty years ago to fifteen years ago.

Mr. Riker: I move that this testimony be stricken out as irrelevant and incompetent. It is within twenty years of the period involved in this suit.

The Commissioner: Note the motion of Counsel for the defendants.

Q. How many are engaged now on the Staten Island
3262 shore in the oyster industry?

A. Practically none.

Q. Are those beds regularly examined now to determine the fitness of the oysters for food??

A. The beds have not been examined very recently, because they are supposed to be unfit for use, but the beds are being tested annually or more than that, several times a year on the borders of where the polluted areas may be and the areas from which they are taken for food.

Q. You are talking now of present conditions?

A. The present conditions of today. Even while we are speaking we have oysters being analyzed at the laboratory for that purpose, to know whether they are fit for food or not.

Q. What laboratory and who, if you know, makes these examinations?

A. The first investigation we had was by Professor Higby of the Brooklyn Research Laboratory and they are being conducted now by the Lederle Laboratories.

Q. Is anybody in particular there conducting these examinations?

A. I really do not know who conducts them. We send them in for analysis and they send us back the report.

Q. Who signs the report that you receive?

A. Dr. Pease generally.

Q. Are the oyster areas that are left now large or small?

A. Very small. There is just that small strip east of the Great Kills Bar extending toward Elm Tree Light and out toward the ocean. Some parts of the Bar being used, not a great deal.

Q. Are those oysters taken from there used in interstate commerce?

A. Yes, sir.

Q. Have you had any difficulty with the Pure Food Law in relation to them?

A. No, only we are under their supervision. They examine the oysters as they are taken from us. We have had them examined on the Pacific Coast several times and in the western states.

3263 Q. Have inspectors from the Agricultural Department visited your plants?

A. Yes, sir.
Q. And made examinations of your oysters?
A. Yes, sir.
Q. Did you ever receive any notice of condemnation of your oysters?
A. Not ours, no, sir, but some of our neighbors have.
Q. What do you think would be the effect on your oysters of an added amount of sewage?

Mr. Riker: The question is objected to on the ground that this witness is not competent to answer it.
The Commissioner: Note the objection of Counsel for Defendants.

A. The effect would be that it would wipe out the business to my mind.
Q. Are you familiar with the currents and their effect on the sewage coming on the ebb tide?
A. Why, somewhat.
Q. When you first went into the oyster business was New York Upper Bay noted for its fish, other than shell fish?
A. Oh, yes, for the shad fisheries particularly, and striped bass and other fish of that kind.
Q. How is it now?
A. Well, you would not want to eat them. They are not caught scarcely.
Q. Did the sewage pollution that you speak of interfere with the ship building yards?
A. Yes, indeed.
Q. In what way?
A. There was a time when the ship building yards of Staten Island were employed almost entirely to build and renew old oyster boats. There was quite an industry on the north and west shores, and now nothing of that kind is being done, no new boats are being built, and very few are being repaired.
Q. Do you know whether or not it is the coarse sewage that floats on top of the water, or the finer sewage in solution that in-
3264 jures you oysters most?
A. Our experience has been that the finer material mixed with the water is what does the injury. Not the coarser stuff that floats on the surface, but our trouble has been with that which mixes with the water.

Cross-examination by Mr. Riker:

Q. Is the oyster propagated in the water or on the land under the water?
A. Well, they are certainly propagated on the land under the water.
Q. So that they would not be affected by water that happened to be on the top?
A. Certainly not.
Q. Are you interested in this company that is raising, gathering and marketing oysters off the Great Kills?

A. What company do you refer to?
Q. Any company.
A. Yes.
Q. Financially interested?
A. Yes.
Q. Is the land surrounding Great Kills populous?
A. Yes, sir.
Q. Are there sewers discharging into it?
A. No, sir, not very much. There are no sewers emptying into the water adjoining the Great Kills inlet or the Bar.
Q. You know that, do you?
A. I certainly do.
Q. Where is the nearest sewer?
A. The nearest sewer is the Staten Island Sound, the Arthur Kill. There is nothing discharging upon the lower side.
Q. Are there any oysters raised to your knowledge within a considerable distance of any sewer outlets?
A. No, there are no oysters raised for food that are near a sewer.
Q. The polluted area that you have been talking about, is it contaminated in your observation by the direct discharges of sewage into the waters?
A. Yes, from the Staten Island Sound waters or the Arthur Kill waters, and that which may come down the Narrows.
3265 Q. And it is only this little section on the Great Kills where there is no direct local sewage contamination which is now being used for propagating oysters?
A. There is no sewage emptying into the Bay outside of the Arthur Kill and the Narrows, nothing emptying into the Bay on the south side of the Island.
Q. It is along the south side of Staten Island where the oysters are now being propagated exclusively?
A. Yes.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. How many acres in that area are now being cultivated, about? I want to get some idea of the area?
A. I should judge about 2,000 somewhere about that, and there has been more than twice that abandoned.
Q. And what would be the number of bushels marketed from that area in one season ?
A. That is a question that would be——
Q. Approximately?
A. Why, possibly a half million bushels.
Q. Has the oyster business been steadily decreasing since your connection with it?
A. Yes, sir, steadily decreasing in Princess Bay and increasing among the Eastern people. That is the business in New York has not got less, but the oysters are being brought from Eastern points

to the New York markets, so New York has lost the market of its own product.

Q. Mr. Riker asked you if the water above the oyster affected it. What do you think?

Mr. Riker: He answered it. The question is objected to on the ground that the witness has already answered the question.

The Commissioner: Note the objection of Counsel for Defendants.

A. He asked the question whether the sewage mixed with the water was most injurious or that floating on the top. I said that the sewage mixed with the water that came in contact with the
3266 oyster direct would be the most injurious.

Mr. O'Sullivan: That is all.

Adjourned to September 18th, 1912 at 10:30 A. M.

3267 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, Sept. 18, 1912—10:30 o'clock a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

WILLIAM T. SEDGWICK, a witness called on behalf of Complainants, and being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Your full name?

A. William T. Sedgwick.

Q. Are you connected with any professional institution?

A. My principal position is that of Professor of Biology and Public Health in the Massachusetts institute of Technology.

Q. Where did you graduate in Biology?

A. I graduated in Biology at Yale University with the degree of Bachelor of Philosophy 1877; studied Yale Medical School
3268 1877-79. Became Instructor in Physiology Chemistry Yale Scientific School 1878-79. Fellow in Biology Johns Hopkins

University 1879-80. Instructor in Biology at the same 1881-83. Doctor of Philosophy in Biology of Johns Hopkins University 1881. Assistant Professor, Associate Professr, Professor and Lecturer on Sanitary Science and Public Health 1883-1910 Massachusetts Institute of Technology. Professor of Biology and Public Health and Head of the Department, Massachusetts Institute of Technology, since 1910. For eight years Biologist of the State Board of Health of Massachusetts. Have been director of the Sanitary Research Laboratory and Sewage Experiment Station, Massachusetts Institute of Technology since 1902.

Q. Are you the author of any works, Professor Sedgwick, in relation to the subjects that you have been identified with?

A. I am the author of works on "General Biology", "Sanitary Science and Public Health" and "Physiology and Hygiene" and of many special papers upon water supply, sewage purification, epidemiology and other aspects of public health science and practice.

Q. Have you been a lecturer on any of these sciences?

A. I have been and am now lecturer on Sanitary Science and Public Health in Simmons College. I hold the honorary degree Doctor of Science Yale University. I am a member of the Advisory Board. Hygienic Laboratory, U. S. Public Health Service. Member and Past-President, Society of American Bacteriologists, American Society of Naturalists, and New England Water Works Association. Member Board of Directors National Association for the study and Prevention of Tuberculosis. Member American Public Health Association. Fellow American Academy of Arts and Sciences, American Philosophical Society of Philadelphia, and other scientific bodies.

3269 —. Are you familiar with the condition of the waters of New York Harbor and its tributaries and if so state to what extent?

A. I am fairly familiar with the waters of New York Harbor and their condition, and of the waters of the tributaries, having for a good many years passed over some of them from time to time, and having, on behalf of this case and for other purposes, made special excursions through the East River, parts of the North River, and towards Sandy Hook and through the Kill Van Kull and Newark Bay to Newark. I have also known the Passaic River to some extent for a good many years having been called to that vicinity in connection with my professional work, so that I think I may say that I am fairly well informed as to the visible condition of the waters of New York Harbor and its tributaries, although I have not myself made bacteriological or chemical examinations of these waters.

Q. Have you examined the Bill of Complaint, the answer and other pleadings in this suit of the People of the State of New York, Complainants, against, the State of New Jersey and Passaic Valley Sewerage Commissioners, defendants?

A. I have.

Q. I direct your attention to the statements made in paragraphs 12, 14 and 15 of the answer filed by the defendants in this suit and to those portions of these paragraphs relating to the effluent proposed

to be discharged from the Passaic Valley trunk sewer outfall, and to those statements relative to the present discharge of sewage into the Passaic River and from thence into New York upper bay, and ask you, as an expert in public health matters and as an authority upon sewage disposal, whether the statements in these paragraphs are reliable or inaccurate?

3270 Mr. Riker: The question is objected to on the ground that the reliability or the accuracy of the statement is not material to the issue.

The Commissioner: Note the objection of Counsel for Defendants.

Q. You may proceed, Professor?

A. The defendants in their answer assert (paragraph 12) that it "is intended to discharge the effluent" at such a place and in such a manner as to "thoroughly assimilate and diffuse it without serious or offensive pollution, and without increasing the present pollution of the bay of New York." But it is manifest that whatever their intention may be, the effect would inevitably be to materially increase the present pollution of the bay of New York. It is proposed to pour into the Bay of New York the screened and settled sewage of a very large population, amounting in the future to some 360 million gallons in round numbers, more or less, per day, and even if this were considerably purified, it could not fail to produce a material increase in the present pollution of the Bay of New York. Defendants further assert in paragraph 14 of their answer "that all or nearly all of the sewage or other polluting matter which is discharged into the Passaic River directly or indirectly below the Great Falls in the said city of Paterson now passes down through the said river and then into the Newark Bay, and finally reaches and is discharged into the waters of the Bay of New York at or near Robbins Reef Light without any appreciable injury to such waters, and without causing any nuisance."

This statement while plausible is absolutely contrary to fact for it is not true that the sewage and polluting matter discharged as described now passes down through the Passaic River, thence
3271 into Newark Bay, and finally into the waters of the bay of New York. If it did so there would be no nuisance in the Passaic and no need for the expenditure of the vast sum contemplated by the Passaic Valley Commission. On the contrary the facts are that the polluting matter here described is, for the most part, retained within the Passaic River where it produces the nuisance which it is designed to abate and does not even reach Newark Bay itself, still less the Kill van Kull or New York Bay. It is for this reason, in fact, that a nuisance exists within the Passaic river, and it would be much nearer the truth to state that the sewage and other polluting material referred to is now retained within that river and there partially but insufficiently purified. The passaic River is in effect an elongated septic tank or sewage purification plant, the effluent from which is emptied first into the Newark Bay, where it is further purified and largely diluted, and from which it eventually, thus

purified and diluted, finds its way into the Kill van Kull, and thence, after still further dilution and purification, into New York Bay itself.

Again it is not true that the sewage and other polluting materials referred to in paragraph 14 are "carried slowly backward and forward by the action of the tides." On the contrary a very large amount of the polluting material is now simply deposited upon the Passaic River, where it remains to ferment and putrefy as if in a kind of cesspool; so that only the supernatant and more fluid portions which lie nearest the purifying atmospheric air are moved up and down the Passaic and finally out into Newark Bay, the Kill van Kull and New York Bay.

It is impossible to emphasize too greatly this important and remarkable purifying action, adundant evidence of which is to
3272 be found in the comparatively pure and wholesome condition of the lower reaches of the Newark Bay through which the effluent from this river cesspool necessarily flows.

Again defendents, in paragraph 15, assert that "the waters of the said Newark Bay which cover a considerable area of land are shallow and do not rapidly take up and assimilate the sewage discharged therein."

This statement is a pure assertion, incapable of exact proof without long and elaborate investigations. But so far as any one can judge from observation upon similar bodies of water, and so far as any one can assert, from what is known of sewage disposal and sewage purification, the statement is absolutely erroneous; for it would be difficult to imagine a body of water better calculated to "rapidly take up and assimilate" sewage. It is, in the first place, sluggish and comparatively shallow. Now sluggishness favors sedimentation, and sedimentation is one important element in sewage disposal and sewage purification. It is also shallow, and shallowness greatly favors the enrichment with oxygen, the indispensable element in sewage purification owing to the penetration of the atmosphere to considerable depths under the influence of winds which readily disturb shallow bodies of water, but affect deep bodies only with difficulty. Again, shallowness is highly favorable for the warming of water, and warmth is an indispensable element of sewage purification. Finally shallowness favors the germicidal action of sunlight, and thereby tends to the destruction of disease germs.

In short, the greater part of paragraphs 14 and 15 of the defendants' answer are, in my opinion, erroneous and misleading.

Q. Have you examined Paragraph 21 of the Answer of
3273 the Defendants, and, if so, will you state whether from the sanitary point of view the waters of the Bay of New York and the waters of Newark Bay intermingling together form one bay or harbor?

A. I have examined the paragraph referred to and I can say that whatever the facts of engineering topography may or may not be, it is not true from the sanitary standpoint that the waters of New York Bay and of Newark Bay form one bay or harbor. On the contrary, each has its own sanitary conditions which affects in its own peculiar way whatever sewage may be deposited within it, and

it would be difficult to find two bodies of water more unlike in their capacity for receiving and discharging sewage than these two bays, one of which is practically an extention of a great tidal river, the other a wide, shallow secluded, landlocked estuary into which the Passaic and the Hackensack Rivers, small and comparatively unimportant streams, pour a limited volume of water.

Q. Speaking as a sanitarian, are you familiar with water sheds, water courses and streams used for sewage disposal and if so state whether or not you consider the proposed place of discharge in New York Bay, that is the proposed discharge near Robbins Reef from the Passaic Valley Trunk Sewer outfall to lie, from the sanitary point of view, within or without the natural drainage area of the Passaic River or valley?

A. I am familiar with watersheds, water courses, lakes, estuaries, and the like as places of sewage disposal and with the natural behavior of sewage, drainage and other polluting materials flowing from watersheds into such streams, lakes, estuaries, and in my opinion the direct conveyance of the merely screened settled sewage of the Passaic Valley as proposed by a closed pipe tunnel or conduit to the place of the proposed discharge at Robbins Reef is in
3274 effect to remove such sewage from its natural watershed and drainage area upon which it now undergoes extensive purification and to deposit it undefecated and putrefying and without natural or adequate opportunity for self purification within the confines of a separate sanitary watershed. In short, from the sanitary standpoint, I do not consider the towns and cities on the Passaic Valley are "riparian" to the waters of New York Bay.

Q. Have you considered from the sanitary point of view the proposed point of discharge of the Passaic Valley Sewer?

Mr. Riker: I object to the question as to its form. It is too general.

The Commissioner: Note the objection of Counsel for Defendants.

A. I have; and in examining any coast survey chart which shows the bottom of the bays and harbors and also the location of the line which separates the State of New York from the State of New Jersey I have been struck with the fact that the outlet proposed is apparently placed just as near the edge of the territory of New Jersey as it possibly could be placed. Indeed, in view of the location proposed, namely, at a remote corner or angle of the territory belonging to the State of New Jersey, I cannot avoid the suspicion that this particularly remote corner was selected for the reason that whatever damage might arise would affect the people of the State of New Jersey comparatively slightly.

Q. Professor will you state whether or not you consider the proposed discharge of sewage near Robbins Reef objectionable and contrary to the public health, interest and welfare?

Mr. Riker: The same objection.

3275 The Commissioner: Note the objection of Counsel for Defendants.

A. I do consider the proposed discharge highly objectionable and contrary to the public health, interest and welfare because, in the first place, such a system of disposal runs counter to the spirit of modern sanitary science, since it proposes to foul still further a body of water already too much polluted, and thus violates the first principle of public health conservation, namely, cleanliness. It is now held by all advanced and highly civilized people that cleanliness is one of the first requirements of a healthful environment, and the purification rather than the increased pollution of rivers, harbors, and estuaries is a watchword of the time. In my opinion it would be an appalling misfortune if the States of New York and New Jersey should go on much longer adding to the vast burden of filth now placed upon the bays and rivers of the Metropolitan District. These bays and rivers ought rather to be reserved forever for the comfort, convenience and business and pleasure purposes of the people. It is a recognized fact of sanitary science that a dirty and especially a sewage polluted environment is prejudicial to the public health, so that it is not only a disgusting but a dangerous condition when Manhattan Island or Staten Island or Coney Island is in fact, as has often been said, "a body, of land surrounded by sewage." The disgust comes from disagreeable and filthy appearance in the water, and I may add from foul smells when these exist. The danger — in the fouling of the air supply among other things for air tainted with the gas of putrefaction is unwholesome air.

3276 Danger comes also in bathing, in fishing, in boating, in commerce; as, for example, in the washing of decks, the handling of wet ropes previously dragged through sewage-laden waters; in spray blown upon the faces, hands, clothing, or material handled; in fishing from the handling of wet fish, and the like; in oyster culture and in the consumption of raw shell fish, such as mussels or snails—food frequently eaten by our domestic and foreign population.

The question of air deterioration is by no means merely academic, for the crowded recreation piers, the crowded excursion steamers, and the crowded shores or bathing beaches, wharves, and other places contiguous to the harbor waters testify to the resort thither of hundreds of thousands of the population, every one of whom normally breathes into his lungs a considerable portion of the surrounding atmosphere eighteen times a minute. This condition is real and not imaginary, any one can testify to it who will take the troublt to enter New York Bay or its contiguous waters directly from the open sea or Long Island Sound, or from a visit to the country when the contamination of the air by sewage gases can often readily be detected.

The Metropolitan area of New York and New Jersey is already a vast human ant-hill teeming with one of the greatest commercial and industrial populations on the face of the globe. The health, comfort and convenience of this huge mass of human beings requires that every practical and reasonable sanitary safeguard shall be thrown around it. Vast sums have already been appropriated for its safe and proper water supplies and much greater sums will

be soon required to prevent its bays and rivers from becom-
3277 ing putrefying, nauseating, and dangerous bodies of sewage.

It is fortunate that so little trouble has arisen thus far, but there will surely come a time, probably during some prolonged hot dry spell of summer weather when the comparatively innocuous fermentations which now go on in these bodies of water in the presence of dissolved oxygen will, in the absence of such oxygen, pass over into evil-smelling, unsightly, disgusting, and dangerous putrefactions, with the result that what is now a comparatively decent and unobjectionable body of water will become a public nuisance and cry loudly for relief. Moreover, when that time comes relief will be difficult to obtain, because the gradual accumulations of years such as are going on today will constitute a mass of filth so great as to be impossible to deal with rapidly or to make wholesome quickly.

Instead therefore of adding to the already too extensive pollutions of New York Bay the State of New Jersey ought in my opinion rather to join hands with the State of New York and set to work immediately to prevent all further pollution to the end that these precious bodies of water shall be reserved forever for the real comfort, safety, convenience, and sanitary welfare of the vast populations which will soon surround them.

I believe that the port and harbor of New York are the most important port and the greatest harbor of the country, and a great center of commerce; many foreign and other steamship lines bring and carry unlimited numbers of passengers; its exports, imports, traffic, and trade, foreign and coastwise, are of the greatest volume and magnitude. The United States government has expended
3278 and is expending great sums of money in improvements in and about the harbor, and in dredging channels in the interest of general commerce and for the benefit of navigation and the general welfare of the country. In and about the harbor it has erected, and and is still erecting at vast expense, important structures, and it is the owner of a very large amount of public property, including forts, immigrant stations, barracks, dwellings, and the like, and these forts, stations, and buildings are occupied by many officers, soldiers, sailors and employees of the United States and their families, requiring sanitary protection and other comforts and conveniences.

Now the effluent discharged from the dispersion area of the Passaic Valley sewer will in my opinion generally be of a higher temperature than that of the water of the bay in the immediate vicinity, and will, therefore, and for other reasons tend to rise and spread out over the surface, making a polluted, evil smelling, foul, and unsightly surface, rendering life uncomfortable and unpleasant to those living in its near vicinity or passing over it while engaged in commerce, travel and pleasure, and will constitute a nuisance, to the detriment and injury of commerce, navigation, and the public health, comfort and convenience.

I believe that the construction and operation of the proposed Passaic Valley sewer will discharge large quantities of putrid matter

into the waters of New York harbor, which matter will oscillate back and forth through the Narrows and through the channels of both upper and lower New York bays, and will tend in part to settle, make deposits and eventually shoal and obstruct navigation in those waters clogging the navigable channels and necessitating the expenditure of further sums of money in maintaining those channels, for example, by the maintenance of dredges, scows and
3279 boats to remove said deposits, while the dredges, scows, and boats thus required will in themselves obstruct navigation, impede commerce, and diminish the comfort, pleasure and convenience of the people of the State of New York. I am of the opinion that all this will tend to make the port of New York less serviceable for commerce and less agreeable and comfortable to the people by virtue, among other things, of the offensive and unpleasant odor and the unsightly appearance of the water, and of the channels, wharves and docks, which will result from the discharge of the sewage in the manner proposed, and by reason of the action of the sewage so discharged which will injure the hulls of vessels and their paint, both exterior and interior, including war ships and other craft belonging to the United States Government, yachts and pleasure boats.

As an example of the importance of the sanitary condition of New York Bay to the people of the State of New York and people generally I may point out that the United States Government owns valuable and extensive property on the upper New York Bay and along the shores of the Narrows, including Government Islands, the headquarters of the Department of the East, United States Army; Fort Wadsworth, Fort Tompkins, and Fort Hamilton; Ellis Island, where all steerage passengers from abroad are transferred from the steamers in which they arrive; Liberty Island—known also as Bedloe Island—on which is Fort Wood, where a United States Army Station is located, and on which stands the Bartholdi Statue of Liberty presented by the French people to the U. S.; an anchor station off Stapleton in Upper New York Bay for war ships; ferry-boats from the Battery to Ellis Island, and from the Battery to Bedloe Island and Fort Wood; also boats which run to and from the various
3280 government stations, the Brooklyn Navy Yard and Sandy Hook; also several lighthouses, and the Brooklyn Navy Yard, the foremost naval station in the country, situated on the East River, with its docks and United States warships under construction and repair; that the government maintains many residences and barracks on these various properties, and I believe that the persons engaged in these government services as well as innumerable visitors, travellers and seamen will be seriously affected, and their health injured, by the discharge of the effluent from the Passaic Valley sewer as proposed, which sewage or effluent will wash up on the shores of some or all of these properties, creating at times an unpleasant and offensive stench, and a nuisance, and rendering life uncomfortable for persons living on the said government properties or passing to and from said properties or otherwise over the bay of

New York, especially near the dispersion area, and will render the said properties less valuable for the purposes for which they are now used and intended to be used hereafter.

Moreover, in as much as the proposed acts of the defendants will be repeated and continued from day to day without limit of time, to the manifest and irreparable injury of the property of the United States and the people of the State of New York, and to the health, comfort, and welfare of people living and employed upon the harbor shores, and to passengers or persons travelling over the polluted area engaged in commerce, I believe they should be forbidden also, in the light of modern sanitary science and engineering methods, I believe that there are other, better, and more advanced methods for the disposal of the sewage of the Passaic Valley than those proposed and planned by the Passaic Val-
3281 ley Sewerage Commissioners, so that the method adopted, which I believe to be to the manifest and continued injury of the commerce and navigation, the public health, the comfort and convenience of the port aforesaid, and the property of the people of the State of New York and of the United States, is neither wise nor necessary.

Q. Have you examined the stipulation agreed to between the United States Government and the State of New Jersey concerning the Passaic Valley plans?

A. I have examined it with a good deal of care, and I believe it to be from the sanitary point of view an unfortunate and unsatisfactory agreement. It seems to me to have been drawn up by engineers rather than by sanitarians and to be unsatisfactory from a sanitary or public health standpoint.

Q. In what particulars do you find that so?

A. My principal objections to it are, first, that it permits the direct transfer of a vast quantity of putrefying liquid to be carried away from its natural purification basin and deposited still more putrid and without purification in the waters of a different sanitary area, to wit, New York Harbor. In the second place, I do not believe that the screening as proposed will remove at all times and under all circumstances materials visible to the naked eye, but that on the contrary, in spite of such screening, these will be carried into New York Bay and be readily visible. Finally, I do not believe that the means contemplated will be adequate to produce the results required. And especially I do not believe that the steps proposed to be taken will prevent either a nuisance or injury to the public health or interference with major fish life in the waters of New York Bay.

3282 Q. Speaking broadly from a sanitary standpoint, what is the present condition of New York Bay?

A. New York Bay is already heavily polluted, and although it is a good example of what can be done by mere dilution in the way of avoiding for a long time an intolerable nuisance, it is nevertheless dangerously loaded with polluting matters and rapidly approaching the time when it will become an intolerable nuisance.

Q. Is your opinion that you have now expressed given merely

as theoretical, or is it based on any experiments anywhere with which you are familiar.

A. My opinion is partly theoretical and partly based upon the striking experience which befell the city of London in 1858 and 1859, when the River Thames previously heavily loaded with pollution became overloaded and caused an intolerable nuisance.

Q. Will you describe more fully that peculiar experience?

A. I will and by reading——

Mr. Riker: Excuse me, Professor. I desire to object to it as incompetent and immaterial.

The Commissioner: Note the objection for Counsel for Defendants.

Q. You may proceed, Professor?

A. By reading from my own book entitled "Principles of Sanitary Science and the Public Health" pages 354, 355 and 356, but before reading the quotation, I may — that this is taken from a famous book on typhoid fever by a distinguished English authority, Dr. William Budd. The quotation is as follows: "For the first time in the history of man, the sewage of nearly three millions of people had been brought to seethe and ferment under a burning sun in one vast open *cloaca* lying in their midst. The result we all know.

3283 "Stench so foul, we may well believe had never before ascended to pollute this lower air. Never before, at least, had a stink risen to the height of a historic event. Even ancient fable failed to furnish figures adequate to convey a conception of its thrice Augean foulness. For many weeks the atmosphere of parliamentary comittee rooms was only rendered barely tolerable by the suspension before every window of blinds saturated with chloride of lime and by the lavish use of this and other disinfectants. More than once in spite of similar precautions, the law courts were suddenly broken up by a insupportable invasion of the noxious vapor. The river streams lost their accustomed traffic, and travelers pressed for time often made a circuit of many miles rather than cross one of the city bridges.

"For months together, the topic almost monopolized the public prints. Day after day, week after week the Times teemed with letters, filled with complaint, prophetic of calamity, or suggesting remedies. Here and there a more than commonly passionate appeal showed how intensely the evil was felt by those who were condemned to dwell on the Stygian banks. At home and abroad the state of the chief river was felt to be a national reproach. 'India is in revolt and the Thames stinks' were the two great facts coupled together by a distinguished foreign writer to mark the climax of a national humiliation. But more significant still of the magnitude of the nuisance was the fact that 5 millions (of pounds) of money were cheerfully voted, by a heavily taxed community to provide the means for its abatement. * * *"

Commenting on this quotation I see on page 355: "Dr. Ord re-

ported to the Privy Council in 1859 that in 1858 (the year
3284 of the worst stench) steamboat men on the Thames suffered severely from languor, headache, sorethroat, nausea, giddiness, mental confusion, &c. (in other words from symptoms of poisoning). In 1859 the river was much better and very few such symptoms occurred. * * * 'In both years the presence of sulphuretted hydrogen in the river atmosphere was shown by the rapid blackening of paper soaked in solutions of lead and by the discoloration of the paint of vessels.' * * * Second report of medical officer of the Privy Council for 1859, p. 55. London, 1860."

Now, concerning these quotations I desire to state that in introducing them and commenting upon them, I point out in by book, that although the symptoms of ill health just described were observed, no epidemic diseases such as typhoid or Asiatic cholera and no great plague or pestilences such as the people had expected to result did in fact occur. On the other hand as already stated, among the rivermen, the members of Parliament, and others upon or near the river, great discomfort and some actual nausea, giddiness and other symptoms of sickness did occur.

Q. Do the petrescent gases that you have mentioned, sulphuretted hydrogen, mathane, those other products of anaerobic bacterial activity, do they deplete the vitality and diminish the resistance to the invasion of disease from other sources?

A. That is the current belief of students of Public Health Science, and while it is not easy to prove it, or to give specific examples, the ones which have just quoted, do it seems to me, establish the fact beyond all peradventure. And furthermore, common human experience shows and teaches that one's condition for work or play, what I may call the fine edge of life can be very materially interfered with and in an unfavorable direction by the breathing of gases of putrefaction.

3285 Q. Is it your opinion, Professor Sedgwick, that fresh air with its usual amount of oxygen, increases efficiency as against foul airs, such as you have described.

Mr. Riker: Counsel for Defendants will admit that it is not necessary to testify to that.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. Riker:

Q. In your various professional associations Professor Sedgwick, have you ever received the degree of Doctor of Law?
A. No.
Q. Have you ever studied legal science?
A. No, never.
Q. And you are not a lawyer?
A. Not a lawyer.
Q. For which you are probably thankful—your are not an expert upon law?
A. Or legal questions.

Q. In expressing your opinion on certain paragraphs of the legal papers in this case, you are simply viewing them from your professional point of view?

A. Simply from the sanitary standpoint.

Q. Now, is it feasible in your opinion, to produce an effluent when discharged at Robbins Reef from the Passaic Valley Sewer which will thoroughly assimilate and diffuse without causing serious or offensive pollutions, and without increasing the present pollution of the Bay of New York?

A. I think it is perfectly possible to produce an effluent which will not cause a serious or offensive pollution, but it probably would not be possible to produce an effluent that would not to some extent increase the pollution of the Bay of New York.

Q. You think it will not be possible to produce an effluent which will produce no more pollution in the Bay of New York than the effluent from Newark Bay now produces in the Bay of New
3286 York?

A. I think it would be entirely possible to produce an effluent, if I understand the question, to produce an effluent which would no more add to the pollution of New York Bay than the discharge from Newark Bay now adds to the pollution.

Q. Then your criticism of the plan is like a number of other witnesses in this case, to the specific devices and processes which you understand are proposed?

A. Certainly, I have no objection to the general purification of the Passaic River. On the contrary, I greatly hope that is may be purified.

Q. And you can conceive of an effluent which can be produced and discharged into New York Bay without any additional injury to the waters of New York Bay?

A. Without any material additional injury, yes.

Q. Well, you say that you have considered the stipulation which is Exhibit No. 135 in this case. If the effluent which is produced will be followed by the guaranteed results contained in that stipulation, do you think that there would be any material injury to the waters of New York Bay?

A. Yes, I think an injury would still result.

A. A material injury?

A. A material injury.

Q. In what would it consist?

A. By adding to the general load of pollution in the Bay.

Q. Will you point out the particular features which in your opinion will be injurious?

A. Certainly. No provision is made here for any extensive purification, so that there would be a large amount of petrescent material poured in there which would tend to reduce the dissolved oxygen and would tent, as I have expressed it, in a general way, to further load the harbor with pollution.

Q. Now, Professor, what are you directing your attention
3287 to in the papers there?

A. I looked over all the items.

Q. Of the guaranteed results?

A. Yes. That is those paragraphs numbered 1, 2, 3, 4, and so on.

Q. Assuming an effluent from which when discharged into New York Bay there will be an absence in New York Bay of visible suspended particles coming from that effluent?

A. Yes.

Q. And assuming an absence of deposits objectionable to the Secretary of War of the United States?

A. Yes.

Q. And assuming an absence of odors due to the putrefaction of organic matters contained in the effluent?

A. Yes.

Q. And a practical absence on the surface of New York Bay of any grease or color due to the discharge of the effluent and that there will be no injury to the public health which will be occasioned from the said sewer, the discharge of the said sewer, and no public or private nuisance created thereby, and assuming an absence of injurious effects from the effluent upon the property of the United States in the harbor, and assuming an absence in reduction of the dissolved oxygen resulting from the discharge of the effluent to such an extent as to interfere with major fish life, in what, in your judgment, will there be a material injury done by the discharge of such an effluent into the waters of New York Bay?

A. It seems to me that assuming all these things to be accomplished, there still remains a great probability I will say of damage to the harbor, because to take them one at a time the invisible suspended particles, the deposits that might be objectionable to other people than the Secretary of War, the coloration in the fourth paragraph, they, while practically absent according to some, might be practically present according to others, and in the seventh paragraph, the reduction of dissolved oxygen to an extent which might interfere with minor fish life and might use up the oxygen
3288 which should be saved for other purposes. All these constitute loop holes in the agreement which seem to me fatal to it from a sanitary standpoint.

Q. The visible suspended particles which you speak of. What damage are they going to do in the way of creating a nuisance?

A. They are going to accumulate and become visible deposits later on.

Q. Then they will become visible suspended particles?

A. They may not for some weeks or months.

Q. They would?

A. They would in that case become visible.

Q. The- the stipulation will not be complied with?

A. I do not see that, because I do not see any limit of time put there.

Q. Then there will be absence in New York Bay of visible suspended particles coming from the Passaic Valley sewage. I ask you if the invisible suspended particles become visible, do you understand the stipulation is complied with?

A. Yes, if they become visible after months or weeks.

Q. Why do you say that, upon what do you base that opinion?

A. It strikes me as common sense.

Q. Will there be absence of visible suspended particles coming from the Passaic Valley sewage if that happens?

A. I should think so, yes.

Q. Where will they come from then, these visible suspended particles?

A. They would not be visible suspended particles, they would be deposits. They would not be in suspension any more.

Q. They are not visible then, are they?

A. Yes, they will be visible.

Q. They will not be visible in the waters?

A. En masse, but not individually in the water coming from the dispersion area.

3289 Q. So the damage that will be done, will then be from deposits which will not have been visible at any time in the waters of New York Bay.

A. That is the point exactly.

Q. What harm are they going to do?

A. They may shoal up the channel and blacken the shore and change over into decomposing materials which will cause putrefactive odors later on.

Q. As a sanitary expert you are willing to say that in your opinion that will happen if the purification of the effluent is of the character that is described in the first paragraph?

A. I am, I think it is probable that it will happen.

Q. Well, if they shoal up the channel, do you conclude that the deposit of this material will or will not be objectionable to the Secretary of War?

A. I have no knowledge of the Secretary of War.

Q. I understand you have not—do you think it would be objectionable to the Secretary of War?

A. I certainly do, yes.

Q. Now, assume that he is a man of reasonable intelligence, Professor, do you think that it will be objectionable to the Secretary of War.

A. I hope so, yes, I should say so.

Q. Then will this stipulation be complied with in your opinion?

A. Yes, because that might come in such a way that it could not be proven to have come from there after a lapse of time.

Q. It is a question or proof not the actual doing of the thing?

A. Most things are a question of proof.

Q. They are in a way, but is not it far more important, the question of doing them in your judgment?

A. That is a fine point which I am afraid I cannot follow.

3290 Q. Where a stipulation provides that certain things shall not be done, do you assume that they will be or will not be, whether it is a question of proof or not?

A. I assume they will not, of course.

Q. If you cannot prove that it is not carried out?

A. I do not know that I follow you there.

Q. Now what other injurious effect did you say you thought would occur if the stipulation is complied with?

A. I said, if I remember rightly, that there might be what one would call a practical absence on the surface of New York Bay of any grease or color, while to another it might be practically present, and it seems to me therefore that that was a worthless stipulation or item. I would not say worthless, that it makes the carrying out of the entire scheme, the administration of the entire scheme difficult, if not impossible.

Q. What part of it did you criticize, the use of the word "Practical?"

A. Yes.

Q. If it were said to be an absence of grease or color, would it not be subject in your judgment to the same objection, that to one person there might be absence, and as to another, there might not be?

A. To a less extent, certainly.

Q. It is a question of degree, not of kind,—that is what you mean?

A. Well, I think that absence and presence are easier to determine than practical absence and practical presence.

Q. The question of proof as applicable to practical absence, is not that question of proof applicable to the oxygen, or the absence on the surface of color?

A. Certainly. I suppose it would be covered. It is a matter of proof in both cases.

Q. The only question of difficulty that you would have
3291 is what constitutes the standard of practical absence as distinguished from absence?

A. So far as that paragraph goes.

Q. That is your criticism of that paragraph?

A. Yes.

Q. Now the other was that the dissolved oxygen might be reduced to a point where it would interfere with minor fish life as distinguished from major fish life?

A. Yes.

Q. Well, what point is that?

A. Nobody knows, but my idea was this. That the seventh stipulation is so indefinite that to begin with nobody knows at what point major fish life will be interfered with by the reduction in the dissolved oxygen, but assuming that that could be established, there still remains other kinds of fish life, and I use that simply as an example of the fact that the dissolved oxygen would be reduced, and thereby the burden laid upon the harbor increased. I used minor fish life only as an illustration.

Q. Well, what special purpose have you in mind for which the dissolved oxygen in the harbor is especially desirable?

A. For the general cleanliness of the harbor. On account of the inevitable pollution that will always get into everything that is used by the public.

Q. And do you or do you not include in that sewage discharged into the waters of the Bay from New York City?

A. Well, I think that should be included, but I did not include it because I was assuming that this material was going in as described, and that the water at Robbins Reef was the water of New York Bay unpolluted by the State of New York. It would still under those conditions be a heavy burden upon that water in my opinion. Not probably an intolerable burden but a heavy burden.

Q. Well, now, to what extent, if it reduced the percentage
3292 of dissolved oxygen, do you think that it would be a burden to the waters of New York Bay, assuming the condition which you seem to have assumed that it should not be polluted by the State of New York?

A. I cannot answer that, because I do not know what the dissolved oxygen would be under those conditions, or how far it would be reduced, but I do know it would reduce it.

Q. You know as most intelligent men know that the introduction of organic matter in any form into the waters of New York Harbor will tend to reduce the dissolved oxygen?

A. Certainly.

Q. And from the exclusive sanitary point of view it is your opinion, is it not, that it is desirable to exclude as much as possible of organic matter from the waters, the harbor or the bay?

A. It is.

Q. And that is about all that you do mean, isn't it?

A. That is about all I do mean on that, yes, although there is a choice in the organic matters to be put in. Organic matter is a very b-oard term. Sewage matter is the worst kind of organic matter.

Q. I would extend it to that point that the organic matter, which is peculiarly a part of sewage, should be, as far as possible, excluded from all waters?

A. Certainly, I should like to see the organic matter increased provided that the organic matters were major fish life, not microbes though.

Q. You would exclude the organic matter from sewage proper so called, from all inland waters, so far as possible?

A. So far as practicable.

Q. Would it not be desirable to exclude it entirely?

A. That depends. There are certain conditions under which a stream or body of water is not good for anything except a cesspool and sometimes it is worth while or might be worth while to
3293 use it for that purpose alone, but that would be very rare.

Q. You do not apply that to New York Bay for instance?

A. No, sir.

Q. And I think you said that you now considered the Island of Manhattan and the Brooklyn shore and Coney Island, and Bath Beach as properly described as bodies of land surrounded by sewage?

A. I said there was great danger that they would become so, and they have been so described. I think I did not say they actually are.

Q. You do not concur in the description of the Island of Manhattan as a body of land surrounded by sewage?

A. Yes, if we say diluted sewage.

Q. And where does the sewage come from which has rendered the Island of Manhattan a body of land surrounded by diluted sewage?

A. Mainly from the Island itself.

Q. Are you familiar with the conditions in the Passaic River?

A. Fairly so.

Q. Well, the conditions there existing, do you think they should be continued and increased?

A. Decidedly not. They are intolerable.

Q. And to the extent to which the Passaic Valley project involves simply the purification of the Passaic River, you approve of it, do you not?

A. Heartily approve of it.

Q. Do you think that it would be a desirable thing to divert the sewage and discharge it into the Newark Bay. Do you think that would be a proper plan of disposing of it.

A. That would not be the proper method of disposal, no.

Q. Do you think that would be a tolerable disposition to make of the sewage of the Passaic Valley?

A. Intolerable.

Q. Notwithstanding its special adaption for purification purposes to which you testified?

A. Notwithstanding that.

3294 Q. By the way you said that one of the elements of the special adaptability of those waters for purification, was the temperature of the water, due to its shallowness?

A. Yes.

Q. Is that a matter of summer temperature?

A. Well, of course in winter it works the other way, but this matter of sewage disposal is very largely a summer question.

Q. You mean by that, that conditions in the summer are more likely to develop injury from the same quantity of sewage by reason of the high temperature?

A. Yes. Of course sewage must be disposed of all the year around, but sewage disposal in winter is a comparatively simply matter so far as the production of a nuisance is concerned.

Q. Do you think there is any less sewage matter discharged from a given community in winter than in summer.

A. Probably more, sometimes.

Q. Now, you have suggested that there was some other plan of disposing of the sewage of the Passaic Valley which would be preferable. Would you mind indicating what you have in mind?

A. I have made no special study of the problem over there, but in going up Newark Bay, the other day, I was struck with the fact that there is a vast body of almost useless water from the shores of which it would be easy to build out enough to locate a sewage purification works for that whole valley. I mean, given a sufficient sum of money.

Q. You understand that the disposal plant that is contemplated in the project is to be located on Newark Bay, do you not?

A. Yes, I do.

Q. And to that extent, the plan that has been adopted, as you understand it, seems to be the one that would be the normal and natural one?

A. It seems to be decidedly so, to bring the sewage down
3295 to some such point as is indicated upon the plan, and there to treat it to such an extent that it could be put directly into Newark Bay without creating nuisance.

Q. Your idea is that the effluent should be purified to the extent where it could be discharged into Newark Bay?

A. Or into New York Harbor.

Q. Or into New York Harbor, either one or the other?

A. It makes no difference.

Q. The effluent in either case should be equally purified.

A. It should.

Q. Do you think that a greater purification or less would be appropriate to the discharge into Newark Bay as compared with the New York Bay.

A. Well, I should think that from the standpoint of public welfare, it ought to be a little better purified, to go into New York Bay than into Newark Bay; simply because, as I have already said, Newark Bay is a remarkable purifying basin as it is, and it would have the advantage in passing of a still further purification before reaching a large population.

Q. But assuming equal financial importance to the shore surroundings of Newark Bay, with those of Newark Bay?

A. I should then make no difference.

Q. Do not you think that it makes any difference that Newark Bay is shallower so far as the character of the effluent which should be discharged into it, is concerned.

A. Yes, I think that in view of its shallowness and of the fact that it oscillates back and forth a good deal less probably that, if it is desired to prevent a nuisance, it would have to be purified fully as much. On second thought, possibly even more than it would in the other case.

3296 Q. Will the fact that the width of Newark Bay is very appreciably less than the width of New York Bay affect the question of the extent of purification, to your mind?

A. I should not think so very much, no.

Q. You do not think the near approach of the same character of improvement along the shore would affect the character of the effluent, shluld affect the character of the effluent?

A. Yes, if the shores are being built upon with the same sort of population and manufacturers, I think that the same remedy should be applied, and especially in view of the fact that there is a smaller volume of water there. I think that the purification would have to be fully as great as it would in New York Bay.

Q. And it might have to be greater?

A. Probably greater, yes.

Q. What injurious effect in Newark Bay in your judgment will be produced by an effluent producing in New York Bay the guaranteed results contained in the stipulation?

A. Well, I think it would produce practically the same results, but possibly—yes, I will not say but possibly—but probably exaggerated because of the smaller volume of water, the smaller movement and the shallower Bay.

Q. You appreciate, Professor, that the plan which is proposed of discharging into New York Bay at Robbins Reef involves the expenditure of several millions of dollars as compared with the discharge into Newark Bay, do you not?

A. I do, yes, and I cannot see why, if all the things in the stipulation should be carried out, and all the results reached, which it is alleged will be reached, that the same effluent might not go directly into Newark Bay without so great an expenditure and
3297 without the production of very much greater nuisance.

Q. But you would anticipate a greater nuisance in Newark Bay?

A. I think it would be somewhat greater, perhaps, decidedly greater.

Q. You have spoken of anticipated injuries in New York Bay from the discharge of this effluent, and one of them, as I remember, was the injury to the property of the United States. If the guaranteed results are produced by the effluent discharged into New York Bay, do you think that the contemplated injury will result?

A. I think it will, yes.

Q. Well, I draw your attention to the guaranteed results that being the sixth item, absence of injurious effects from said sewage discharged upon the property of the United States situated in the Harbor of New York?

A. Of course, if all injurious effects are avoided, there will be no injurious effect. That is perfectly obvious.

Q. That seems to be an absolutely logical inescapable conclusion?

A. I see no escape from that.

Q. Now, I ask you again that if the effluent discharged into New York Bay produces the guaranteed results, do you mean to say that you think there will be any injury to the property of the United States in the harbor of New York?

A. No, logically speaking. Paragraph 6 seems to cover all that point.

Q. That seems to exclude the injuries which you testified to?

A. But I do not believe that the means proposed will produce the results guaranteed.

Q. Well by that you refer to the sedimentation and screening processes?

A. Yes.

Q. And you do not have in mind any requisite additional arrangements?

A. I do not understand.

3298 Q. I say have you in mind the agreement on the part of the Passaic Valley Sewerage Commissioners to adopt other requisite lawful additional arrangements?

Mr. O'Sullivan: I object to that question on the ground that it calls for a juridic interpretation of what is and what is not lawful relative to additions to the plant described.

The Commissioner: Note the objection of Counsel for Complainants.

A. I have noted that provision and I have no doubt that additional arrangements could be made which would do away with all my sanitary objections. Whether these would be lawful or not, I am unable to state.

Q. Not being a lawyer?

A. Not being a lawyer and not being familiar with the statutes of New Jersey or of those municipalities.

Q. So far as you are acquainted with additional processes and devices for purification, do you know of anything that is unlawful about them?

A. No, although I have observed, that one of the first things that people have to do in these cases is to go—in Massachusetts—is to go to the Legislature and get authority to issue bonds and to go beyond the debt limit and to do all sorts of legislative and legal things before the work can begin.

Q. Well, would in your opinion not the same dilemma present itself to you if the word "lawful" had been left out of the stipulation. In other words, in your opinion, can the State of New Jersey or the Passaic Valley Sewerage Commissioners undertake to do anything that is not lawful?

Mr. O'Sullivan: The same objection.

The Commissioner: Note the objection of Counsel for Complainants.

3299 A. They can undertake it, but whether they can carry it out I suppose might be a question. Now, I think if the word "lawful" were omitted and if I were satisfied that these commissioners could get the necessary funds when the time came, I should consider that pretty satisfactory.

Q. A pretty satisfactory result to be obtained?

A. Because all I ask is that there shall be requisite additional arrangements.

Q. To produce the guaranteed results?

A. To protect the people of the State of New York or to avoid a nuisance or injury to the public health of New York of New York Bay.

Q. If the guaranteed results are produced by the specific things or by additional requisite arrangements, is it not your opinion that the result would not be satisfactory?

A. No, I cannot say that is is. I think I could draw up a better set of protective arrangements than this.

Q. Professor, have you in mind that the City of New York, which we are assuming for the purpose of this question as having four million and a half inhabitants of its own, is discharging crude sewage into these waters and do you think that this stipulated result, or these stipulated results could be said by any one to be other than satisfactory, for the effluent from the State of New Jersey discharged within the territory of the State of New Jersey?

A. I certainly do.

Q. You think that while New York is discharging crude sewage to such an extent into the harbor that the State of New Jersey should be prevented from discharging any sewage into the harbor, is that your view?

A. No, I think that sewage effluent should come in and I think that New York should be prevented from doing the same
3300 thing that I would ask to have New Jersey prevented from doing.

Q. And do not you think that before New Jersey should be prevented from doing these things that New York should be prevented from doing what she is doing?

A. If that were practicable, yes.

Q. Whether it is practicable or not, what do you mean by practicable?

A. I mean that it would be comparatively easy to construct in the New Jersey scheme as here laid down, and comparatively difficult to stop New York putting in its sewage, New York City.

Q. Comparatively easy. Now what do you mean by that, Professor?

A. I mean that it is simply a matter of money to take the sewage there on those meadows and do the thing, whereas it is not simply a matter of money in the case of New York.

Q. Why, isn't it?

A. Because of the magnitude of the problem. There is great danger that if New York should spend hundred of millions in putting its sewage somewhere, that it would still not be satisfactory. The magnitude is so enormous. It needs in both cases, I say, the most careful study. What I hope is that the two states will get together and appoint a joint sewerage commission and study this thing out.

Q. With the idea that the state of New Jersey should incur expense in order that the State of New York should be saved from expense.

A. The reverse.

Q. Why in your opinion should not the same degree of cleanliness apply to the State of New York as applies to the State of New Jersey?

A. I would only exact the same from each.

Q. Why would you not require the same effluent from the State of New York that you would require from the State of New Jersey?

A. I should be very glad to require it, only in one case it seems

to me within the bounds of human labor within a reasonable
3301 time. In the other case it seems to me beyond our power within the same time, but eventually I hope to see both of them acting up to the same degree of cleanliness.

Q. Is it not impracticable in your judgment, for New York to adopt the same standard of cleanliness that you think is appropriate for the State of New Jersey?

A. No, sir, I think they ought to have the same standard. It is perfectly practicable, but it would probably take a long time to work it up.

Q. And where would you suggest the discharge of this purified effluent from the State of New York?

A. Why, I should hope it would be good enough to put right into the bay in both cases.

Q. Would it be an effluent in your judgment of any higher quality than that which is guaranteed in this stipulation?

A. It certainly would.

Q. It would in what respect?

A. I should want to see it put through some sort of a filtration plant before being put into New York Bay. It is possible that either of those might be carried out to the deep sea, either the New Jersey or the New York sewage. If it could be carried far enough, but that is a very serious question that I do not feel sure about.

Q. You think that it is practicable for the State of New Jersey to carry its sewage from the Passaic Valley out to sea?

A. Except for the expense.

Q. Is not that the thing that you said was impracticable for New York in the matter of the expense?

A. I think it may prove to be so at present, but I hope in the future that New York will be able to afford anything.

Q. You would suggest that New Jersey be compelled to carry its sewage by a long line discharge pipe out into the ocean?

A. I have not suggested anything of that kind. I only
3302 said that it was possible to do it, without producing nuisance.

Q. You say you think that is a possibility?

—. I think it is a possibility, barring the financial question.

Q. It is possible for New York to do the same thing?

A. Entirely.

Q. Are you aware that this stipulation is entered into under the direction of the responsible officers of the Government of the United States?

A. I suppose so.

Q. And you are disposed to criticise that, are you not?

A. I am, yes.

Q. You set up your judgment as against theirs?

A. Unfortunately I have to do so.

Q. You have in mind the fact that these matters to which you have testified are the matters which they had under consideration and discussion?

A. I presume so, I have no doubt of it. It is simply, as I said, I believe they were mostly engineers rather than sanitarians.

Q. Do you know?
A. No, I do not.
Q. Then why do you say it?
A. Judging by the result of their work.
Q. Now if you were called upon to introduce into this stipulation matters which you think are essential, what would you suggest?
A. Well, as I have already intimated, I should be disposed, although I have not made a study of the whole problem, such as ought to be made by any one who is making the stipulation, I should be disposed to require some form of filtration.
Q. Well, Professor, do you think that the specification of any particular form is more effective than to say that by requisite lawful arrangements certain results should be obtained?
A. Yes, I think so, because it is specific. The other is
3903 loose general, it seems to me.
Q. You lay more stress then upon specifying the processes or devices rather than the results, do you?
A. No, I think I should be willing to be guided by the result, but I should make the result one which could only be reached by certain processes.
Q. Let us hear what the result is that you would suggest?
A. I should require a result as for example that the putrescibility should be looked over, and I should put such a standard as would practically require filteration.
Q. Anything else, any other change that you would make?
A. I think that is the principal thing.
Q. And you would retain the other provisions of the guaranteed results would you?
A. As far as I can say without being put in such a responsible position as that.
Q. How much reduction of putrescibility would you require?
A. I should not be willing to say off hand. I think it would require a good deal of study.
Q. Do you think 10 per cent. of the putrescible content is enough?
A. I should think that might do. I am not sure though without more study than I have given it.
Q. Will the devices which are specified in the stipulation reduce the putrescible matter more than 10 per cent.?
A. I think it is possible that they will, yes, taking the crude sewage.
Q. Then you would require more than 10 per cent.?
A. If that is so, yes.
Q. Have not you made any investigation to determine how much the processes will affect the petrescibility of the sewage?
A. Yes, but there are so many different processes, and the sew-
3904 ages vary so much. Trade wastes and all sorts of things, here, for instance, the presence of acid, acids interfere with the action of bacteria. The question is too complicated to answer off-hand. That is a part of my objection to this stipulation, that they do not seem to have been studied with sufficient care. I

am certainly not willing to answer that without a good deal of study and care.

Q. But the chief amendment that you would introduce would be a degree of putrescibility in the effluent, is that it?

A. I should think that would be one of the principal things, perhaps the principal thing, although I should want the organic matter, the materials all looked carefully over. The trouble now is that this proposes to put a load of septic or putrescent sewage into the Bay. I would avoid that somehow.

Q. Why do you designate it as septic or putrescent sewage?

A. Because it would be stale by the time that it reached Robbins Reef and staleness means septicity and putrescity.

Q. So that notwithstanding the treatment that it is to receive and notwithstanding that it attains the results which are guaranteed,——

A. Certainly notwithstanding the treatment. Of course if all these results can be reached, and are reached, particularly at all times and all seasons, it is possible that no material damage will come, but I do not feel certain that is the case, and I do not feel certain that these results will be reached all the time.

Q. Are you certain about anything in this life that is in the future?

A. Not many things, no.

Q. Except you are reasonably certain of the rise and fall of the tide and the rise and setting of the sun?

A. There are certain things——

Q. And death and taxes, those you are reasonably certain
3305 about, but any other things, you cannot be certain that they will occur. Any form of stipulation depends, does it not, upon whether it is actually carried into effect?

A. Certainly.

Q. A paper stipulation does not carry itself into effect?

A. Not necessarily.

Q. But assuming that these stipulations shall be carried into effect by the Passaic Valley Sewage Commissioners, do you think that it is a proper description of the effluent to say that it will be septic and putrescent when discharged at Robbins Reef?

A. Yes, I think it will, because I do not see anything in these stipulations, or requirements which will prevent that. They do propose to prevent odor and deposit and color and grease and damages and so on, but there is nothing said about their preventing putrefaction or septicity.

Q. Well, those Latin derivatives are not in themselves terrible, are they?

A. Generally not.

Q. What are the injurious things which will accompany in your judgment this sewage described by these derivatives in New York Bay if the stipulation is carried out in good faith and according to its terms?

A. It is as I have already said. If septic, stale and putrescent sewage arrives in that Bay it will in the first place so to speak devour or absorb oxygen, and that diminishes the resources of the harbor.

Q. But, Professor, you have already said that there were certain waters which in your judgment were very appropriately devoted to cesspool purposes?

A. Certainly a few.

Q. The reduction in the dissolved oxygen of those waters would not be injurious?

A. No.

Q. In what respect is the reduction of the normal oxygen in the unpolluted waters of New York Harbor likely to be injurious in your opinion?

A. Only as rendering those waters less capable to handle whatever inevitable contamination came in from the water shed.

3306 —. How much reduction in the normal oxygen content of the pure waters of the Bay of New York as we may imagine it to have existed, when Hendrik Hudson first sailed up it, do you think will produce results which are at all likely to be injurious in any respect?

A. Of course that would probably have to be a very large reduction, but we do have such reduction by deposits in the waters—in drinking waters. The bottoms of some drinking water reservoirs are destitute of oxygen and are stale and stinking, so that they have to draw the water from the top. I am not talking merely about theoretical conditions there. There is a real use for the oxygen of an unpolluted water in looking after the disposal of the inevitable organic matters which find their way in, the dead fish and washings from the near fields in agricultural districts.

Q. You are not thinking of the waters in New York Bay as potable waters?

A. I do not suppose that the oxygen in the normal New York Bay was ever so reduced.

Q. Do you concur in the view that it is safe to reduce the oxygen in the waters of New York Bay to 50 percent.?

A. I should doubt very much if it was, because with the increased population and the inevitable pollution, even if every town on the Hudson River and the City of New York and all the rest should purify their sewage, they have got to put the effluent somewhere. That effluent will undoubtedly take some oxygen no matter how good it is and that effluent plus the inevitable pollution that I have referred to will eventually make it so that we must not reduce the oxygen in New York Bay even to 30 per cent. by sewage.

Q. Even by 30 per cent. you mean?

A. By 30 per cent. leaving 70 per cent. oxygen, yes.

Q. Do not you know that the oxygen in the East River is now reduced to 55 per cent.?

A. I dare say it is at times, a good deal lower in some

3307 places.

Q. And on an average don't you know that that *it* is a fact?

A. Yes.

Q. And at the mouth of the Hudson River don't you know that the oxygen averages about 55?

A. Yes, I think that is dangerously low.

Q. Now, assuming the normal oxygen content in New York Bay unaffected by the contaminations, do you think the discharge of the effluent as guaranteed in this stipulation, assuming the maximum population, will that effluent reduce the oxygen content, and how much?

A. It is a mere guess, but I suppose it might in that case mark it down in the immediate vicinity of the discharge to 70 per cent, I should say.

Q. Professor, when you say the immediate vicinity, won't you indicate what you have in mind?

A. I mean within a range of half a mile, and that, of course, only at times. It would depend on the rush of the water and all sorts of things.

Q. Take the whole content of New York Bay, if you have any way of judging what is it. Have you any idea what the diminution in oxygen would be from this discharge?

—. Very small. Probably infinitesimal. Assuming the bay to be unpolluted.

Q. You have testified in your direct examination with reference to riparian conditions so far as they are involved in sewage disposal. How far do you think the proper riparian territory extends from any given point. For instance, take the Passaic River at the Center Street Bridge in Newark. How far up the stream do you think a fair riparian right of discharge at that point might exist?

A. I should suppose all the way up.

Q. How far down?

A. It is more a matter of down than up.

Q. How far down then?

A. I should suppose to the mouth of Newark Bay, for instance. That is the natural drainage area of that region, and it is where the tides go back and forth and things settle.

3308 Q. And so far as the territory, we will say, at Elizabethport, do you know where Elizabethport is?

A. In a general way, yes.

Q. So far as property along the shore at Elizabethport is concerned, you think that the right to discharge sewage at Elizabethport belongs to the whole ripa upon the river as far as Paterson?

A. I should think there it was shared with Elizabethport, that region. Yes, I should think they had certain rights there, but not the principal right.

Q. You think that Paterson would have the right to come out with its sewage and discharge it at Elizabethport?

A. Not the principal right, no.

Q. Is it not a fact that the sewage of Paterson discharged in the upper regions of the Passaic River will have been very measurably purified by the time it reaches Elizabethport?

A. Yes, and that is just the basis of my idea, that the true sewage riparian right is at Elizabeth. From there down the right diminishes from the purification.

Q. And that applies to all the towns and villages upon the river to the head waters of the water shed?

A. That is it exactly.

Q. So that there is theoretically no more objection in time, not in degree, but in time, to the discharge of the sewage into New York Bay within the territory of New Jersey than there would be to discharging the same sewage at Elizabethport, for instance?

A. I suppose that is true in kind rather than in degree as you say.

Q. If the effluent which would normally reach New York Bay by means of what you term the natural sewage disposal is produced, of a character which will not materially affect the waters of New York Bay, what is the objection to that effluent?

A. There is not any.

Q. Have you not said that the effluent which is guaranteed here will not in your judgment produce any materially greater or
3309 more injurious effect on the waters of New York Bay than the effluent from Newark Bay does produce?

A. No, I do not think I said that.

Q. I thought you did?

A. I said the effluent might be put into either of the two. If I did say it, it is not true, because the processes of purification in Newark Bay are of such a kind as to make a materially different effluent from that which is proposed to be put into New York Bay.

Q. You think the effluent from Newark Bay is of better quality than that which is guaranteed to be produced under these stipulations?

A. I do decidedly.

Q. In what respect?

A. It is settled and fermented and a naturally self purified effluent. The other is a septic and putrescent effluent, which has only been settled and screened.

Q. You do not think the sewage from the Passaic River when it is discharged from the Newark Bay in the form of a natural effluent is septic?

A. I should doubt if it was a good deal of the time. It did not look so the day I saw it. I saw it from the Bay, out in the Bay.

Q. Why is not it septic?

A. Because it apparently contains oxygen.

Q. It has been purified then?

A. Yes, that is just my point.

Q. In your judgment there is not any injurious effect from the discharge into the waters of New York Bay at the present time of the effluent from Newark Bay?

A. Comparatively little.

Q. Is there any?

A. I do not know. I have not studied it enough to know.

Q. Do you remember me asking you some question along this line earlier in the cross examination?

A. No, I do not.

Q. Do you remember saying that in your opinion the results

would be practically the same from the effluent as is now produced from the effluent from Newark Bay?

A. No, I do not.

Q. If you did say it, do you desire to withdraw it?

3310 A. I do, decidedly.

Q. What in your judgment is included in the water shed of New York Bay?

A. That all depends on whether one is speaking from the point of view of an engineer or from the point of view of a sanitarian. From an engineering point of view the usual answer would be given that all the region which sends its water into the bay is on the watershed, no matter how remote or through what devious channels, but from the sanitary point of view the watershed of New York is simply the immediate vicinity draining directly into it. That is to say it is New York City and Brooklyn and Jersey City and Staten Island, parts of it, and Bayonne, the east side of Bayonne, whatever is immediately in contact with that bay.

Q. How far up, in your judgment, in distance does the immediate contact extend as you understand it?

A. I should think that that would be very difficult to determine. It would be a small distance probably up the river, say opposite New York. Wherever the sewage came in and polluted the water as such. If the sewage was transported, self purified en route, to any appreciable extent, I should say that at that point, we were departing from the sanitary watershed. There might even be a question whether the upper part of New York City would come in under my definition.

Q. Is it not a fact that the transmission of sewage in a water course tends to purify it?

A. In a general way that is true, yes, tends to purify it, yes.

Q. So that the discharge of any sewage from the actual point of production at any point below the distination point is a diversion from its proper point?

A. It certainly is.

Q. So that every sewer then is a diversion?

A. Some purification begins even in the sewer itself.

Q. I ask you whether every sewer from that point of view

3311 is not a diversion of the sewage from its natural disposal channel?

A. At the same time sewage does not change with infinite rapidity, and a reasonably small amount of time is certainly required to make it anything but sewage.

Q. Are you familiar with the Bronx Valley Sewer?

A. No, I do not know much about that.

Q. Don't you know whether that is a diversion of the sewage?

A. From what I have heard about it, I should suppose it is distinctly.

Mr. Riker: I think that is all for the present.

Dedirect examination by Mr. O'Sullivan:

Q. Mr. Riker asked you Professor Sedgwick, if sewage transported in a sewer was not a diversion of that sewage from its natural watershed. I ask you if that organic matter transported in the sewer was deposited upon the land, if it would be washed through the water shed into the river that drained the watershed in the normal, natural operation of the element?

A. It certainly would.

Q. You have made a distinction between an engineering water shed and the sanitary idea of a water shed. I ask if you took into consideration in making this distinction the scavenging agency in water, whose function is the purification of the organic sewage matter that is discharged at normal points along that water shed?

A. Yes, it is that process of self purification that I had in mind. A partical- of water, pure water falling on a water shed remains a particle of water from the time it touches the ground until it reaches the sea and thereafter, for that matter, but a particle of sewage produced or falling upon the water shed, is subject to change by natural agencies, so that after a longer or shorter time it may even
3312 cease to be sewage, and it is for that reason that I feel strongly that there is a great distinction between a sanitary watershed and what I would call an engineering watershed. The term of course is not good, but I believe there is a distinction there.

Q. And in the illustration of the application of that principle through an answer to Mr. Riker relative to Paterson and Elizabethport, you stated that the sewage discharged at Paterson, that Elizabethport was entitled to this purification agency or its operation on that sewage, rather than having it discharged in concentrated form. Is that a fact?

A. In my opinion that is a fact.

Q. You described the Passaic River as an elongated septic tank, and the portion of Newark Bay as a sedimentation basin. Is the decanted effluent that comes on the ebb tide better in quality in its oxygen content than the waters that it enters in New York Bay?

A. Undoubtedly at certain seasons it would be better than the water that it entered, but I should think that at other seasons it would not be. It might be worse. That is another illustration of what I mean by the difference between a sanitary water shed and a water shed as ordinarily so called. Processes are at work which purify the sewage and they are summed up in the general term self-purification, but to make a general statement that these would always be at work, and always produce a particular result is impossible. They probably would not.

Q. Will screening and sedimentation remove organic matter in solution from sewage or colloidal matter?

A. Only very slightly.

Mr. O'Sullivan: I think that is all.

Recross-examination by Mr. Riker:

Q. Now, Professor, what in your judgment is the distinction between the rights of the City of Elizabethport near the bay, the City of Elizabeth, and the City of New York to complain of the discharge of an effluent of the sewage of the City of Paterson when discharged at either of those two points?

Mr. O'Sullivan: I object to it unless it is qualified to the
3313 extent of requiring that opinion from a sanitary standpoint, because the question as it lies includes a juridic opinion.

The Commissioner: Note the objection of Counsel for Complainants.

A. The two points being Elizabethport and Robbins Reef?

Q. Yes.

A. And assuming that the same material is coming to both?

Q. Assuming the same effluent?

A. Why, I should think that Elizabethport or Elizabeth had the same right to complain as the State of New York, because in both cases the natural self purification is cut out and the material is piped directly to them.

Q. And in locating an imaginary sewage disposal plant on Newark Bay, which would serve the Passaic Valley, you think that injury is one that could be complained of by the City of Elizabethport properly from a sanitary standpoint of view?

A. Not assuming that a decent effluent is produced, because Elizabeth now has to endure an effluent from a natural purification plant, the Passaic River and Newark Bay. I should say Elizabeth in that case would have no right to complain provided the effluent were as good as the material now flowing out of Newark Bay. I should hope it would be better.

Q. So that from a sanitary point of view, your judgment is that if the effluent was not materially more objectionable from the sewage plant than it is from the natural sewage disposal plant, the artificial sewage plant, than it is from the natural sewage disposal plant, there is no ground of complaint?

A. That I think is perfectly obvious. They have the right now to use the river, to be protected by the river and the bay, and if the effluent were as good as it now is, they would have no right to complain.

Q. Do you think as a matter of fact the up river towns have the right to discharge their sewage into this stream, known as
3314 the Passaic River so as to produce as effluent of the character which exists at Elizabeth?

A. I suppose they have or they would not be doing it.

Q. I am talking from the sanitary point of view?

A. No, not from a sanitary point of view, no indeed, I think that is highly objectionable.

Q. And that is objectionable from the point of view of the City of Elizabeth?

A. That would still be objectionable to Elizabeth.

Q. Now, assume, if you please, that the City of Elizabeth is polluting its own border, so that the effluent which is proposed to be discharged is of a higher quality than that of the waters immediately surrounding the City of Elizabeth. What then do you think of the sanitary situation as to the matter of the rights of the City of Elizabeth?

Mr. O'Sullivan: I object on the ground that it is calling for a juridic opinion from this witness as to the rights of the municipality.

The Commissioner: Note the objection of Counsel for Defendants.

A. It seems to me that Elizabeth has no moral right to object unless she has cleaned or is about to clean her own skirts.

Mr. Riker: That is all.
Mr. O'Sullivan: I think that is all.

Adjourned to September 20th, 1912, at 10:30 A. M.

3315 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

CORPORATION COUNSEL'S OFFICE,
NEW YORK CITY, September 20, 1912—10:30 o'clock a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

PAYN B. PARSONS a witness called on behalf of Complainants, recalled for further examination, testified as as follows:

Direct examination by Mr. O'Sullivan:

Q. You testified previously in this suit?
A. Yes.
Q. Are you still holding a position with the Metropolitan Sewerage Commission?
A. Yes, I am.
Q. And what is that position?

A. Bacteriologist.

Q. Are you actively engaged in the performance of your duties?

A. Yes, every day.

3316 Q. Dr. Parsons I hand you Complainants' Exhibit No. 195 and ask what you know in relation to it?

A. Well, this is a report that I made to Dr. Herbert D. Pease, Vice President of the Lederle Laboratories in 1910. Filed report signed July 1st, 1910. I made this report while working for the Lederle Laboratories and it consists of report of the Sanitary Conditions along the Staten Island shores abutting on the Lower Bay, and was made in connection with the oyster industry, and this is the report as I handed it in to Dr. Pease signed by me.

Mr. O'Sullivan: Your witness.

Mr. Riker: No questions.

Mr. O'Sullivan: That is all, Doctor.

WALTER BENSEL, a witness called on behalf of complainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your profession, Doctor?

A. I am a physician.

Q. Where did you pursue your professional studies?

A. At the College of Physicians and Surgeons in the City of New York.

Q. When did you graduate?

A. Graduating in 1890.

Q. Did you pursue the practice of your profession after that?

A. I have, ever since that time.

Q. Did you pursue your studies anywhere else?

A. Well, I pursued various studies in various hospitals. I do not know that they have anything to do with this particular experience. I was in Bellevue Hospital for two years, the Vanderbilt Clinic, and in the Polyclinic Medical School and Hospital where I was a lecturer on Surgery. In 1892 I entered the Department of Health and have served continuously from 1892 to the present date in various grades, until I now hold the commission—a civil service grade, the highest that can be held in the Department.

3317 Q. Are you a member of any professional bodies?

A. Many medical societies.

Q. Have you contributed to the literature of your profession?

A. I have not had a great deal of time to write, Dr. O'Sullivan.

Q. Do you now hold an official position?

A. I am Sanitary Superintendent, attached to the Department of Health, of the City of New York.

Q. Have you got assistants under you?

A. Five of them, one for each Borough. The Sanitary Superintendent, I might mention, is the chief of the Sanitary Bureau, and the Sanitary Bureau is about four fifths of the Department of Health.

Q. Are you the chief of that Bureau?

A. I am the chief of the Bureau; I also hold the position of head of the Department of Hygiene and Preventive Medicine, Columbia University.

Q. Are you familiar, Dr. Bensel with the harbor waters of New York?

A. In the course of my official duties it has become necessary many times to take action with respect to conditions which have arisen from harbor pollution.

Q. Now, taking the North and East Rivers, will you state their condition?

A. The condition may be stated in several different ways. In the first place the North and East Rivers are polluted to very considerable extent, so that it has become necessary for the Department to take action to limit the bathing which is allowed, along various situations, until at present the public baths have been reduced to about 5 in Manhattan, 4 in Brooklyn, and 2 in the Bronx. That is along all the water front of those three boroughs, there are now only 10 or 11 baths. This has been due entirely to the condition of the water which renders it unwise to allow bathing
3318 to any greater extent. These baths even this Summer were allowed merely as a tentative proposition with the idea of further cutting down the number next year, providing the City could make other arrangements for bathing for the people that required it. There is a great deal of trade waste which is run into both the North and East Rivers, and of course this trade waste is of a highly putrescible or decomposible nature. At the present time, with sufficient oxygen, it does decompose. It is a question of how much more pollution could be added, before, instead of decomposition taken place, putrefaction will take place, and very offensive conditions arise. Putrefaction does take place and has taken place at the mouths of sewers, so that in ferry slips, even at the present time, the nuisance in hot weather is so great as to be an offence to common decency. It is a common belief that the odors which arise from fields, such a field as is found at Rikers Island, is due in large part to the character of the material which is placed there. As a matter of fact it is due much more largely, probably in 75 per cent. of the nuisances, to the character of the bottom of the river or the harbor which is being filled in, and which is caused to rise above the surface of the water by the pressure of the filled in material. The deposits of decomposing material, while they are kept at the bottom of the river or harbor, do not cause any great annoyance, but as soon as they are brought above, and exposed to the elements, then they become very, very offensive. So that is another one of the causes of pollution of the waters of the East River, and that is one of the things that our Department has to take action concerning very frequently.

3319 That is about the situation so far as the North and the East Rivers are concerned, as far as the Department of Health is concerned.

Q. Now, how is it with the ferry slips?

A. I have just mentioned that many of the sewers empty directly into ferry slips, and as a consequence the waters being more or less confined, are extremely offensive, so much so that in summer time the conditions are really serious. There is another matter that might be mentioned, along the shores of Manhattan and the Bronx, also of Brooklyn on the East River the deposit of decomposing material on the piles and on the docks on the shore fronts. These deposits occur at high tide, sometimes at very high tide, and they remain and flies accumulate more or less on them, gathering the filth on their feet and carrying that to foodstuffs in the neighboring markets or houses. There is no question but what a great deal of filth is carried to foods in just this way.

Q. Do you regard flies as a medium of infection?

A. There is no question but what flies carry typhoid fever in a great many cases. Just what proportion, it is very difficult to say, because there is a large proportion of typhoid fever cases, wherein you cannot find the cause, the actual transmitting agent.

Q. Are the odors offensive from these deposits that you speak of?

A. So far as Manhattan and the Bronx are concerned, not so offensive as some other parts of the city, but at times and in the neighborhood of sewers they are very offensive.

Q. How do they affect the oyster beds of the City or the oyster supply as to the oysters themselves, Doctor?

3320 Going back about 35 or 40 years ago, there were considerable oyster beds on Spuyten Duyvil Creek, and these oysters were esteemed a very great delicacy, a very excellent oyster. Those have gone out, become exhausted absolutely and entirely, because the waters have become so polluted that they no longer grow there. In some of the waters emptying into New York Bay directly or indirectly, for example the Rahway River, and for example the creek at Port Richmond, Staten Island, the oyster industry there has been practically killed, on account of the pollution of these streams. Princess Bay, which was formerly a very great center of the industry is diminishing, becoming less and less as time goes on, simply for the reason that the pollution of the water interferes with the growth of the oysters. In Jamaica Bay so far as the oysters are concerned, the waters are not sufficiently polluted to prevent their growth and they do grow and to all appearances, and to the taste they are wonderfully good oysters. There is no evidence whatever at the present time that the waters of Jamaica Bay are so polluted as to interfere with the healthfulness of the oyster in the beds. But, unfortunately it is the practice of the oystermen to take their shell fish from the beds and to keep them for a longer or shorter time, freshening them, as it is called, in various semi-brackish or brackish waters in the neighborhood of the oyster beds. These creeks are all more polluted than is the bay at large, and as a consequence, the oysters have not infrequently been infected by them. Within the last year there was an outbreak—not an epidemic, but an outbreak—of typhoid fever in one of the little towns of New York State, Goshen,

3321 which was traced undoubtedly to start with, to oysters, taken from the beds in Jamaica Bay and freshened in a creek outside the limits of the City of New York.

Q. What do you mean by freshened?

A. I mean taken out of their beds, carried up into the creeks that have a less salty content, than the waters of the Bay from which the oysters have been taken. In other words, there is a difference in the specific gravity of the water in which they are placed and the water from which they were taken. They take up the water in the freshening places very rapidly, and they become plump looking and more appetizing in appearance to certain people, and that has become a common factor and has developed in practically all the oyster industries in the country. There is a further reason for that, however. During a certain part of the oyster season, the waters over the oyster beds are so frozen in so that the oysters cannot be dredged up, and therefore have to be gotten up early in the season and stored in these floats in creeks for the demand during the Winter.

Q. Do the deposits from trade wastes affect these oysters as to their marketable quality or their properties for food?

A. The deposits from trade wastes undoubtedly affect the oysters in two ways. In the first place, they may give them a taste which will render them obnoxious so that there is no marketing them. On the other hand they may discolor them, and in the third place, the trade waste may be so great as to interfere with their *nutrition* and growth.

Q. Now, as to the trade wastes, taking Gravesend, Bay Ridge and Staten Island, that region, Doctor? As to the trade waste and pollution generally what do you say?

A. It has prohibited to a very large extent, the use of those beaches for bathing purposes. The waters are so contaminated that
3322 a person must have a little sense of decency to bathe in them. They are covered with all sorts of floating material, and the bathing beaches not only have on them decomposing vegetable matter, but considerable quantities of fecal matter that has floated up on the tides.

Q. Does that give rise to any odors or deposits?

A. Gives rise to odors from the deposits on the shore, and not only that, but the deposits of fecal matter on the shores gives rise to infection by means of flies. We regard that as a very serious menace. We believe to a certainty that in many instances outbreaks which may not have started from flies in this way, have been kept up by flies alighting in fecal material, not necessarily becoming infected in that fecal material, but developing to such an extent, that they are in large numbers in certain localities, and so spreading the disease which started in some other manner.

Q. Do you believe that these deposits are harmful in this way?

A. I know they are. I have seen flies and maggots actually in these deposits. As a matter of interest, not as bearing on the question of harbor pollution, but as to showing how flies will develop in that material, in the case of an outbreak, we had very recently, in my practice in Bay Ridge, numbering about 200 cases we found a great many flies developing in this fecal material in the interior of houses that were being constructed, where the workmen had not proper facilities, and they would simply go from their work down into the

cellar and defecate, and the flies grew and developed and laid their eggs there and simply became very numerous in consequence. The same thing is certain to happen when that material is cast up on beaches and left in the hot sun.

3323 Q. In that way do you regard it as a menace to health?

A. I do, decidedly, sir.

Q. Is the sewage discharged into Jamaica Bay discharged in a crude state?

A. Yes, and no, Dr. O'Sullivan. There are four sewage disposal plants on the margins of Jamaica Bay that were built to take care of the sewage, and to so alter it that it would be at least innocuous, at least inoffensive. As a matter of fact the chemical examination and bacterial examination of the material after it has passed through these sewage disposal plants is very little better than the material that is brought to them. It simply means that the sewage is advancing in such tremendous bounds that it gets ahead of the plants that are constructed, and the plants are overloaded practically before they are finished.

Q. The resulting purification would amount to what?

A. I doubt very much if the purification amounts to 10 per cent. on the average in these particular plants. That is nothing against the plants, understand. That is not a criticism of the plant, it is simply a criticism of the amount of material that the plant does not care for. There is a great deal of material discharged into Jamaica Bay without passing through plants which have not room to pass it through either.

Q. What do you regard as the general effects of this sewage contamination?

—. I think there are two effects. There certainly is occasional—there is disturbance to health by means of transmission of infectious diseases, that is the transmission of typhoid. That at the present time is the only disease that comes from the bowels and which is regularly transmitted from one person to another through the discharge from the bowels. If there were cholera, undoubtedly we would have cholera transmitted in the same way, so that flies developing in this material which is cast up on the beaches undoubtedly can transmit transmittable diseases in that way. In

3324 another way, a little more indirect is the effect from the odors, the nuisance from odors. A person who is exposed to offensive odors day after day, gradually loses his appetite, and as he loses his appetite, he loses his sustenance, and his general health suffers, and he becomes a prey to any contagious disease that ordinarily he was not susceptible to, and in that way I think it is a very serious menace to health. Aside from that there are many people who are simply exposed occasionally to the offensive odors, and while their general health may not suffer, nevertheless they should be protected from that nuisance.

Q. Exposure to these noxious odors, do you regard that as in any way interfering with the vital resistance of people, to the encroachment of disease?

A. I do in that way, in the way of interfering with their sus-

nance, interfering with the appetite, so that they do not get the proper quantity of food. It is stated and believed by many people that the breathing of some of these gases, instead of breathing the normal content of oxygen, pure atmosphere, may affect the health also. As to how far that does affect health, in my mind I am not sure, in the open air. I know in houses of course and any confined atmosphere, it does have an effect, but I think that other more important, the disturbance of digestion and appetite, simply resulting from offensive odors, constantly breathing them.

Q. Do any symptoms that you know of follow in the wake of inhaling these putrescent gases, such as nausea, headache, symptoms of that kind?

A. Nausea, lack of appetite, disturbance of the bowels, depression and headache and a tired sort of feeling are very very common among people exposed to them.

Q. Are you familiar with the conditions at Newtown Creek?

A. Very. Hardly a day goes by but what I have complaints concerning the obnoxious odors in and around Newtown Creek,
3325 and I may say that these odors are due to the discharge of trade wastes into the creek. There are very few dwellings in the neighborhood and the offensive conditions I feel are largely responsible for the lack of dwellings and the lack of people living in the neighborhood. They cannot stand it. Newtown Creek is in effect an enormously large sewer, nothing more and nothing less and decomposition has practically given place entirely to putrefaction.

Q. Do you regard that as the result of anærobic action?

A. Entirely to anærobic action. There is so much material to decompose that there is not oxygen enough to allow of ordinary decomposition, and it simply takes place in the absence of oxygen and by means of the anærobic bacteria.

Q. What results would you apprehend as a sanitarian from the volume of sewage proposed to be discharged through the Passaic Valley trunk sewer outfall into New York upper Bay?

Mr. Riker: The question is objected to as it does not appear that this witness has any knowledge with respect to the matter in question.

The Commissioner: Note the objection of Counsel for Defendants.

A. We would simply have a steadily increasing amount of decomposible material. Eventually we would have such an amount that the conditions on the Newtown Creek would practically repeat themselves.

Q. On a larger scale?

A. On a tremendously large scale. There would be so much material that the amount of oxygen contained in the waters at present that can be used for that purpose would be unable to produce ordinary decomposition and putrefaction would take place, if not entirely, to a large extent and tremendous offence would arise.

3326 Q. Would you expect a nuisance to arise from the conditions?

A. A nuisance in that way, a further nuisance of deposit, more or less of solid material on the shores of the bays, harbors and rivers.

Q. Would coarse screening and sedimentation in your opinion remove the possibility of such offensive conditions?

A. The very best kind of screening under the most scientific supervision would probably remove in the neighborhood of 10 to 15 per cent. Beyond that, it probably would not affect it. That has been the experience of other cities that have resorted to screening as a method of purification.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. Riker:

Q. Doctor, you were asked about the discharge of the proposed Passaic Valley Sewer and have expressed an opinion as to what it would eventually do? Do you mean by that testimony that the Passaic Valley Sewer discharge itself would produce this tremendous nuisance that you have testified to?

A. It would simply add to the already existing conditions. I do not mean that it in itself, and alone by itself, would produce this nuisance.

Q. Then if your testimony on the direct was to the effect that it would produce that result, you do not mean it?

A. Yes, it would add to the existing conditions so as to produce the result.

Q. I ask you whether the discharge itself and by itself would produce this tremendous nuisance that you testified to?

A. Alone by itself.

Q. Yes.

A. No, sir.

Q. Would it produce any nuisance by itself?

A. It would.

3327 Q. In what respect?

A. Exactly in the same respect as described for those already in existance.

Q. Where would it be discernible?

A. Wherever it discharged into New York Harbor.

Q. How would it be discernible?

A. In materials that would be cast up on the beaches at high tide and left to decompose and materials that would stay in the water, decompose or putrefy in the water.

Q. What is the character of the discharge that you have in mind that will produce these results?

A. The ordinary character of sewage containing trade waste, decomposible material and containing large quantities of animal excreta.

Q. And do you contemplate any treatment of this sewage before it is discharged?

A. I have already understood that it is to be treated by screening and sedimentation without chemical action.

Q. That is your understanding?

A. That is my understanding, yes.

Q. Do you understand what character of effluent is guaranteed

to be produced by the stipulations made by the State of New Jersey and the United States Government?

A. I do not.

Q. You do not know anything about that?

A. No.

Q. Do not you think you are a little bit rash to testify without knowing that?

A. Only two things, be treated, as the question asked, by sedimentation and by screening.

Q. I think the question was what the proposed discharge would result in, and it appears that you do not know what the discharge is?

A. There is not any discharge at the present time.

Q. I said the proposed discharge and not the present discharge. Now, kindly pay attention to the question and answer it.

3328 Don't you think that you are rash in testifying to a proposed discharge when you do not know what it is proposed to do?

A. No, I do not, because I have a knowledge of sewage disposal plants and have a knowledge of how they work.

Q. Have you a knowledge of whether or not an effluent can be produced, that will not cause a nuisance?

A. I know it can be.

Q. Do you know whether that is or is not the effluent that is guaranteed to be produced by the Commissioners in the stipulation made between the State of New Jersey and the United States?

A. I know this——

Q. Will you answer the questions please?

A. I do not know what the guarantee is.

Q. Are you familiar with the recreation piers of the City of New York?

A. Very.

Q. Where are they located?

A. One at 24th Street, Borough of Manhattan, one in the neighborhood of 100th Street, Borough of Manhattan, one in the neighborhood of 129th Street, Borough of Manhattan, one I think it is 50th Street, Borough of Manhattan,—those are the ones I am most familiar with.

Q. Take the 24th Street recreation pier. How near is that to a sewer outlet?

A. I do not know where the nearest sewer is.

Q. Have you not observed the conditions about the public recreation piers?

A. There is nothing about the recreation piers which would interfere with the health of people on that pier.

Q. I asked you whether you had investigated?

A. I have observed the conditions.

Q. What are the conditions in the slips of the Pennsylvania Railroad adjoining the recreation pier at 24th Street?

3329 A. So far as the health of those using the recreation pier is concerned, very good.

Q. I ask you what are the conditions of the water as to pollution?

A. Polluted. It is polluted.

Q. Now you have said there were five public baths maintained this summer off the Manhattan shore?

A. Six, I said.

Q. Six.

A. Two of them are at the Battery, two of them on the North River front and three on the East River front. They have been placed in various places trying to get some place that was not at all offensive. We regarded, I might say, we regarded the placing of public baths anywhere along the North or East River front as impracticable, and the question of whether they are placed in one place or another had little to do with our action of this summer.

Q. You have taken a chance in other words?

A. We are taking a chance.

Q. How far from the shore front are they placed?

A. Some of them next to the bulkheads, some near to the ends of the piers, depending upon the outlet of the sewers in the neighborhood of the individual bath.

Q. Have they or have they not been located during the summer within the polluted area?

A. They have.

Q. Polluted by untreated, crude, raw, fresh sewage?

A. Yes.

Q. How does the condition of the baths at those baths in your opinion as an expert compare with the conditions of the bathing beaches that you have testified to?

A. Which bathing beaches?

Q. What bathing beaches have you testified to?

A. On the Gravesend Bay, Bay Ridge.

3330 Q. The ones that you testified to, Doctor?

A. The waters in which they are situated are more polluted than they are at the bathing beaches.

Q. Are you familiar with the condition of the beaches along the ocean front in the vicinity of places where the New York garbage scows dump their loads?

A. I do not know that I quite understand your question, as to where the scows dump their loads. They dump them on the shores of Barren island.

Q. Do you remember when they used to discharge them at sea?

A. Used to discharge them at sea—only the quantity of garbage that happened to be mixed with ashes. These scows have not been dumped at sea for a great many years.

Q. How many years?

A. Well, it is 12 or 15 years certainly since garbage has been dumped at sea.

Q. Did you ever visit the beach at Long Beach and Arverne before that period?

A. Yes, I have.

Q. Have you seen the mottled assemblage?

A. I know the conditions very well, have seen them many times.

Q. Have you seen the water filths, the municipal filths and all sorts of garbage along the shores?

A. That cannot be attributed to the dumping of garbage scows. A great deal of that comes from passing steamships.

Q. It is very offensive?

A. In hot weather, yes, very offensive.

Q. Are you familiar with the Jersey shore at Long Branch, along there?

A. Yes.

Q. Have you seen the accumulation of material along those shores?

A. Prior to this dumping at sea, yes.

Q. Now, on the beaches that you have testified to on your direct examination, what part of the objectionable matter that was
3331 present, what part was garbage and what part was sewage, was any part garbage?

A. Yes, undoubtedly a large part of it was garbage, undoubtedly.

Q. Are you aware of the fact that Jamaica Bay oysters have been condemned by the United States Government?

A. They have not been condemned by the United States Government. I am not referring to any newspaper report, but they have not been condemned by the United States Government.

Q. You know that, do you?

A. I do. As soon as the United States Government condemns them, they will not be allowed to be shipped from one state to another. That has not happened so far as to the Jamaica oysters as yet.

Q. Your judgment is that the oysters from Jamaica Bay are a fit food product?

A. Yes, and I know some of them are not a fit food product, particularly after they have been taken from the oyster beds and put in waters which do not produce a fit food product.

Q. As taken from the waters of Jamaica Bay, as they come from the waters of Jamaica Bay, do you think they are a fit food product?

A. From some, yes, from some, no, depending entirely on the depth of the water, the amount of the tide, the amount of flow and the amount of contamination of the water over them.

Q. And the amount of contamination in the water over them, does that in your judgment depend upon the proximity of local sewers?

A. Very largely, yes.

Mr. Riker: That is all.

Mr. O'Sullivan: I think that is all, Doctor.

THEODORE HORTON, a witness called on behalf of Com-
3332 plainants, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your profession, Mr. Horton.

A. Sanitary Engineer.

Q. Are you connected with any of the state departments?

A. The State Department of Health.
Q. In what capacity, what official capacity?
A. As Consulting and Chief Engineer.
Q. Where did you pursue your studies in engineering?
A. At the Massachusetts Institute of Technology.
Q. When did you graduate?
A. 1894.
Q. Just state your experience since then, Mr. Horton?
A. May, 1894, to June, 1895, sanitary Engineer and Agent for Montclair Board of Health, Montclair, New Jersey, on work of reorganizing and framing of general health and plumbing ordinances, inspection and testing of all plumbing; investigation of the pollution of all streams traversing the towns; inspection of all dairies supplying milk to Montclair; inspection of all nuisances; design and construction of a small plant for the disposal of cess pool matter; study of method of night soil and garbage disposal; investigation and report upon the cause of a typhoid epidemic in Montclair; study of vital statistics of Montclair and surrounding towns, chemical analysis of some 60 well and public water supplies in laboratory furnished by the board.

June, 1895, to October, 1895: Assistant Engineer on street and road construction in Bureau of Local Improvements, Brooklyn, New York. This position was obtained through competitive civil service examination. During this period also passed successfully (with rank No. 2) civil service examination for general inspector of granite pavements.

3333 October, 1895, to April, 1896: Assistant in Engineering Department of Massachusetts State Board of Health; on sanitary inspection of the water sheds of new water supplies of the State; calculations for determining the yield and storage in connection with same supplies; hydraulic calculations relative to the new sewerage systems of the State; on the special study of the improvement of the Neponset meadows (including two cases of water power damages based upon the methods of the Metropolitan Water Board); hydraulic field observations of flow of various streams in relation to the yield of watersheds; other miscellaneous studies and calculations.

April, 1896, to August, 1901: With Metropolitan Sewerage Commission as outlined below—From April, 1896, to May, 1898, Assistant on maintenance studies and day work construction; two series hydraulic experiments upon the flow in the Metropolitan sewers, yearly studies relative to tributary areas, flows, per capita rates, leakage, etc., in charge of pumping station records, involving daily calculations of quantities pumped, coal, lifts, duties, etc., monthly observations of losses of head in all the syphons of the North Metropolitan system; in charge of the tide gauges, records, and various tidal studies, calculations of monthly observations of flow from the various cities and towns of the Metropolitan district——

Q. What Metropolitan District was that?

A. The Boston Metropolitan District.—Preliminary surveys and contract plans of sections 53 and 55 of the North Metropolitan Sy-

tem; lines and grades for a new coal pocket at the Alewife Brook Pumping station; also lines and grades and calculations for various retaining walls and embankments, rip-rap, regulators, pumps, etc.

3334 May, 1898, to June, 1899: Principal in charge of lines and grades for additional pumping plant at the four pumping stations for the commission (including pump-wells, suction and discharge channels, engine and boiler foundations, reservoirs, etc.;) special hydraulic studies and calculations connected with the North Metropolitan and Charles River systems;

June, 1899, to Sept., 1900: Assistant Engineer in charge of special hydraulic studies and calculations connected with the High-Level Sewer. Have submitted some 20 special studies and reports upon various hydraulic and structural features connected with the High-Level System, the more important of which are the following:

1. Design and study of anticipated losses of head for the various periods of High-Level Sewer crossing under Stony Brook, Neponset River, Roslindale Brook and depressed section in Hyde Park (6 reports).

2. A study of the reversion of grade of the lower portion of the Charles River system and proposed suction sewer to the Ward Street pumping station with resultant hydraulic conditions for future periods.

3. A study of the bearing power of the soils in the vicinity of the proposed Ward Street pumping station.

4. A study for an auxiliary water supply for condensing purposes for the Ward Street pumping station.

5. A set of piezonmeter experiments upon losses in the suction and discharge channels of the new pumping plant of the Alewife Brook pumping station.

6. Design and study of hydraulic conditions for culverts for seven tidal areas to be impounded by embankment of High-Level Sewer in Quincy.

7. Study of the flood discharges and resultant scouring
3335 velocities of Stony Brook at the point of the crossing of the High-Level Sewer.

8. Study of the hydraulic conditions in the two proposed force mains leading from the new Ward street pumping station under the varying conditions of discharges and manipulations of pumps.

9. Report upon three series of current meter observations made in the sewers of the North Metropolitan System.

10. Design of two brook crossings (in Chelsea and Melrose) on extensions of the North Metropolitan System.

11. Study of hydraulic conditions which will obtain in the two outfall mains of the High-level area under varying conditions of discharges and tides.

12. Various reports upon some 25 efficiency and duty trials to study the improvements of the new Blake centrifugal pumping plant installed at the Alewife Brook pumping station.

September, 1900, to August, 1901: Assistant Engineer in charge of special hydraulic studies and calculations connected with the Metropolitan Sewerage System, and in charge of maintenance of the

North Metropolitan System. The more important work during this interval has been as follows:

1. In charge of the official duty and capacity trials of the additional pumping plants installed at the four main line pumping stations (three triple-expansion Corliss engines and centrifugal pumps of 60,000,000 gallons capacity, and one Blake compound engine and pump of 13,000,000 gallons capacity).

2. In charge of all maintenance work previously classified under my experience to May, 1899.

3. A final study of ground-water leakage of the local systems of the Metropolitan districts and eastern Massachusetts.

3336 4. Earth pressure studies of two retaining walls on line of High-Level Sewer.

5. Study of valuation of Blake pumping plant at Alewife Brook pumping station (not up to contract requirements).

6. Equilibrium study of 150 foot chimney and foundation of Ward Street pumping station.

7. Design of 100 foot chimney with foundation for Nut Island screen house.

8. Earth pressure study of all, and special designs of four, foundation walls of Ward Street pumping station, screen house, etc.

9. Study of probable ground water yield at points on High-Level Sewer.

10. Design for siphon to replace present Mystic Valley Sewer under Abbajona River.

11. Preliminary studies for sizes and sewer routes for various areas of the Metropolitan Sewerage District.

12. Some 20 other studies of reports of minor importance.

August 1901 to date: With Hering & Fuller, Consulting Engineers, as follows:

August 1901 to May 1904: Principal Assistant Engineer in charge of general office work (and occasional field work) in preparing plans, specifications, estimates of cost and assisting on reports for water supplies, sewerage systems, sewage disposal, water power, garbage disposal, pump testing, etc. This work includes principally, sewerage systems for Sacramento, California, Trenton, N. J., Morristown, N. J., Portland, Me., South Nyack, N. Y., Red Bank, N. J., Manzanillo, Mexico, Fort Totten, N. Y., Galesburg, Ill., York, Pa., Ferncliffe, New York, Atlanta, Georgia, Trenton, New Jersey, Lexington, Kentucky, Water Supplies of Hackensack, New Jer-

3337 sey; Water Company, Fort Totten, New York, Ferncliffe, New York, Meadville, Pa., Manzanillo, Mexico and Columbia, Pa., also studies connected with water supplies of Brooklyn, N. Y., New Orleans, Louisiana, New Haven, Connecticut, Springfield, Massachusetts, hydrographic studies of Mississippi, Missouri and Illinois Rivers in connection with Chicago Drainage Canal; hydraulic studies connected with Charles River Dam Boston, Mass.; designs and preparation of plans and estimates of cost for the Passaic Valley Trunk sewer under the two last Commissions: (See Report of Passaic Valley Commissioners, about 1902) in charge of official duty trials of pumps of Meadville, Pa., and Columbia, Pa. Water Works

May 1904 to August 1904: Engaged by Town of Montclair, N. J., in preparing plans and report upon system of storm water drainage system.

August 1904 to August 1906: Resident Engineer for Hering & Fuller in charge of construction of York, Pa., Sewerage System; construction of dam, roof and lining for Reservoir of Columbia, Pa. Water Company, and landscape development of tract of land about 100 acres owned by P. A. & S. Small Land Company, York, Pa. During this period was employed by Pennsylvania State Department of Health on investigations reports and preparation of plans for collection and disposal of sewage of Harrisburg, Pa., and on other sanitary engineering investigations and reports.

August 1906 to date (August 1911): Consulting Engineer to New York State Department of Health as Chief of Sanitary Engineering Division and Director of the Sanitary Engineering work of the Department, including investigations, reports, and advice concerning engineering matters relating to Public water supplies, public sewerage systems, water purification, sewage disposal, stream pollutions, public nuisances, garbage disposal, typhoid fever in-
3338 vestigations and other matters relating to public health and sanitation.

References are given to the following publications of the writer:

No. 1. A report in the "First Annual Report of the Montclair Board of Health."

No. 2. "Investigation of a typhoid epidemic in Montclair, N. J.," published in the Medical Record for October, 24, 1894.

No. 3. "A form of Mass Diagram for determining the yield of watersheds" published in the Engineering Record for July 31, 1897.

No. 4. "Hydraulic Diagrams for the Discharge of conduits and Canals," by Charles H. Swan and Theodore Horton, published by the Engineering News Publishing Company, New York.

No. 5. "Flow in the sewers of the North Metropolitan Sewerage System", published in transactions of the American Society of Civil Engineers Vol. XLVI.

No. 6. Discussions on "Garbage disposal", Trans. Am. Soc. C. E. Vol. L.

No. 7. Discussions on "Centrifugal pumps" Trans. Am. Soc. C. E. Vol. L1.

Published reports and addresses in the Annual Reports of the New York State Department of Health for 1906, 1907, 1908, 1909 and 1910.

Q. Mr. Horton, what special official connection and experience with the studies and reports of the Passaic Valley Sewerage & Drainage Commission have you had?

Mr. Riker: What is the name of that commission—I do not know of any such body in New Jersey.

The Witness: It is the official title some ten years ago. It took "drainage" in with it.

3339 Mr. Riker: All right; go ahead.

A. About the year 1900, if I remember correctly.

Mr. Riker: One moment, however, I desire to object to the question as being immaterial and irrelevant to the issue.

The Commissioner: Note the objection of Counsel for Defendants.

A. During the first and second commissions 1900 or 1901, as Assistant Engineer for the firm of Rudolph Hering and Geo. W. Fuller, I was in charge of the designs for the Passaic Valley Trunk Sewer, which was being developed, under those two commissions. The second commission, in 1901, I think it was, I had charge of the designs at the time that Mr. Fuller had charge of the field work. That was all reported in the reports of those two commissions.

Q. Have you inspected and studied the conditions in New York Harbor waters with reference to the Passaic Valley Trunk sewer project?

A. I did very particularly about that period, during those studies and investigations. Since that time I have incidentally done so in work incidental to the department and during my frequent visits in the vicinity. More especially at the time of the investigations of the smoke nuisances on Constable Hook when I was continually passing through these waters, New York Bay and around the Kill van Kull and the harbor in general.

Q. What inspections did you make of the Passaic River and Newark Bay?

A. I made inspections of Newark Bay and the Passaic River particularly during the times when I was studying the Passaic Valley project, when I was connected with the firm of Hering & Fuller around 1900 or 1901. Since that time I have not made a special study of the Passaic River, although I have passed it on one or two occasions incidentally and have observed the conditions.

3340 Q. What inspections have you made of the shores of the waters of New York Harbor and vicinity since say 1910 incidental to your work as an official in the Department of Health, the State Department of Health?

A. By frequently coming to New York City, and in some cases with special reference to sanitary investigations. One I referred to just previously, the Constable Hook investigation, which incidentally afforded an opportunity for very careful observations of the conditions in the harbor. I passed in boats and I was out in a boat very frequently on Constable Hook, Staten Island, the lower part of New York and at other times I have observed along the water front the conditions of the harbor, the pollution of it.

Q. Now, what studies have you made in New York Harbor and it its tributaries since 1902?

A. I have made studies with special reference to certain sanitary projects such as the Bronx Valley Sewer. At that time I made a very detailed study of the general conditions around New York and of the pollution of New York Harbor and the Hudson River and incidentally the Bronx River, which was involved in this investigation. A lengthy report of mine is published in regard to that in the annual report of the State Department of Health 1900 and—I cannot give you the year—about the time that it was first approved by the Commissioner and the State Engineer.

Q. Have you made any oyster investigations?

A. In 1908 I was in charge of the field work, examination of the oysters of the waters of Long Island, including New York Bay, Jamaica Bay and Long Island, also including the waters adjacent to Staten Island. Since that time, this present year, I have continued studies or rather been engaged in continuous studies of the pollution of shell fish in these same waters but more particluarly with reference to Jamaica Bay.

3341 Q. Have you conducted any investigations relative to the Passaic Valley Sewers at any time?

A. At the time of my connection with the firm of Herin & Fuller when they were working upon this project, the project of the first two commissions in 1900, which of course is preliminary, but not very different from the complete project as it now stands, I made numerous studies working for practically—a considerable portion of two years on the project. Since that time I have made no special study of the Passaic Valley project, except as it was incidental to questions that have been submitted to the State Department of Health, to the commissioners, as I say, incidental studies in connection with the questions which have arisen in connection with the department.

Q. Now, relative to the literature on this subject, Have you studied the Passaic Valley Sewerage Commissioners reports?

A. I have read them, yes, sir.

Q. The New York Bay Pollution Commissioners' Report?

A. I have read practically all of them.

Q. And the Metropolitan Sewerage Commission's Reports?

A. I have done them also.

Q. Now, from these inspections and studies of New York Harbor and its tributaries, and the Passiac River and the Newark Bay, what conclusions *fo* you draw relative to the harbor and its tributaries in the vicinity of New Jersey?

Mr. Riker: The question is objected to on the ground that it is in effect a hypothetical question based upon matters which are not in evidence in this cause and not matters of proof, and that the question is not in proper form as a hypothetical question.

The Commissioner: Note the objection of Counsel for Defendants.

3342 A. The question refers to the present pollution?

Q. Yes.

A. My conclusions as to the present conditions of the harbor are that there are numerous local nuisances, and that the harbor in general is beginning to approach a state of general nuisance arising from odors floating coarse and suspended sewage matters, grease, discoloration, deposits of sewage mud. The diminution of the digested capacity, due to the exhaustion by the domestic sewage discharged into it, the reduction in the dissolved oxygen, which is now very much depleted, and which if it is not checked will ultimately and presumably in the near future be entirely exhausted, or be so largely exhausted as to create a general nuisance.

Q. Have you studied the Passaic Valley Trunk Sewer project itself, Mr. Horton?

A. I have.

Q. State what your studies consisted in?

A. Very specifically the entire project in the years 1900—in 1902, when I was in charge of the design of the Passaic Valley Trunk Sewer. Subsequent to that time I have followed it in the reports of the Passaic Valley Trunk Sewer Commission and the Metropolitan Sewerage Commission reports and I have seen the plans of the commission as to what the project comprises. I have also studied it in connection with the Bay Pollution Commission and the Metropolitan Sewerage Commission.

Q. Have you reached any conclusion as to the result and efficiency of the project?

Mr. Riker: The question is objected to on the ground that the efficiency of the plant as such is not an issue in this case.

The Commissioner: Note the objection of Counsel for Defendants.

A. My conclusion is that the plant as proposed, and as I
3343 understand it is to be from the plans which I have seen, is of considerably low efficiency. The screens and sedimentation basins will remove but a small portion of suspended and objectionable matter, probably not over 5 to 10 per cent. of the total, and probably not over 10 to 15 per cent. of the organic matters. It will remove only a small portion of the grease.

Q. Now from your studies of the Passaic Valley Trunk Sewer project, what results would you expect to follow its operation and the discharge of the sewage as proposed into New York Upper Bay.

Mr. Riker: The question is objected to because it does not yet appear that this witness knows what the character of the sewage is that is proposed to be discharged into the Bay.

The Commissioner: Note the objection of Counsel for Defendants.

Q. You may proceed?

A. It is my opinion that a local nuisance will be produced in the vicinity of the outlet, and a general nuisance for a considerable distance from the proposed outlet, due to suspended matters, grease and sleek and discoloration, a sewage treated as it is proposed to be treated, will cause deposits which will slowly accumulate in many parts of the harbor, more particularly in the vicinity of the outlet. It will deplete the dissolved oxygen and will destroy—will damage the water for shipping, shipping and industrial purposes. It will blacken the paint on vessels and interfere with pleasure usese of the water such as boating and fishing, and will interfere with the fish life. It will endanger health first directly through the bathing beaches, infecting the bathing beaches and floating baths, or through infections received at these places. It will also affect the fishing and
3344 boating and the shell fish pollution. Drift wood which has been gathered in the waters or from the waters which have touched or floated in the waters nearby this pollution, and there will be danger to health from the exposed shores and wharves

through the medium of fly transmission. There will be danger from the use of water used for washing boats, where this water is taken from portions of the harbor and bay where the pollution will reach. There will be danger from the dredging operations, which will cause this mud to be brought more into suspension, and sometimes brought out upon the surface, where it may become a source of infection. Indirectly there will be a danger to health due to the depression of the human system and the lowering of vitality or vital resistance of people who are subjected to the odors, or who are in the vicinity of the water- that have been grossly polluted by the sewage. These odors and the general obnoxious appearance and offensive conditions will depress the human system and lower the vital resistance to the attack of disease germs. This is of course a secondary danger or menace to the health.

Q. Have you studied the stipulations entered into by and between the United States and the State of New Jersey and the Passaic Valley Sewerage Commission?

A. I have.

Q. Will you state what you find the practicability of its enforcement and its effectiveness to be——

Mr. Riker: The question is objected to on the ground that the witness is not an expert as to the practicability of the enforcement of a legal document.

The Commissioner: Note the objection of Counsel for defendants.

A. From an engineering standpoint?

Mr. Riker: The question is objected to when it contains
3345 that addition on the ground that it is not a question of practicability at all. It is a question of the legal effect of the instrument.

The Commissioner: Note the objection of Counsel for Defendants.

A. I am of the opinion that the works guaranteed in the stipulation One would not accomplish the results guaranteed in stipulation Two. At least only partially so. In expressing this opinion more specifically, I will say first with reference to the section where it is stated that there will be an absence in New York Bay of suspended particles, it is my opinion that the tanks and the screens will remove only a portion of the suspended matters. The remainder will be plainly visible in the vicinity of the outlet and for a considerable distance from it.

The stipulation stating that there will be absence of deposits objectionable to the Secretary of War, although I do not know what the Secretary of War may think—what objection he may have to it, in regard to there being deposits, this will not be accomplished and there will be considerable suspended matter which is heavier or will become heavier than the harbor water. These will be carried to distant points or settle at near points where the velocity is checked, some settling near the outfall and others at distant shores or quiescent parts of the harbor. When once settled, they will remain there probably with less tendency to be carried again in suspension. In other

words the power of the velocities must be much faster than the depositing velocities in order to start a particle in motion which had once become settled.

With reference to the stipulation which states that there will be absence in New York Bay and vicinity of odors due to the
3346 putrefaction, this will not be accomplished. The sewage will be stale or septic when it reaches the outlet. Under ordinary conditions and generally during summer months, these odors will be detected in the vicinity of the outfall. Under unfavorable conditions, moreover, warmer seasons, slack waters, quiet atmosphere and high humidity, these odors may be detected for considerable distances from the outfall.

With reference to the practical absence on the surface of New York Bay of grease and color, this will not be accomplished. There will be a zone of marked discoloration in the immediate vicinity of the dispersion area which may extend to considerable distance from it. The proposed works will not remove all grease and as a result sleek will be plainly visible, especially with quiet atmosphere, for considerable distances from the outfall.

With reference to the stipulation that there will be no injury to the public health and no public or private nuisance, this will not be accomplished. In regard to the public health the sewage discharged will contain infectious material which will be carried to distant waters and shores. This infected material will cause danger to health by affecting the bathing beaches, boating and fishing, shell fish, driftwood, dredging operations, and through the medium of flies, that may be on the exposed shores and docks and through the medium of water that may be used for deck and other purposes in ships. A nuisance will be produced at the outlet or elsewhere affecting yachtmen, ferry boat passengers, fishermen, and industrial concerns, which will result from odors, discoloration of the water, suspended and floating matters, sleek and grease, deposits and the blackening of paint.

With reference to absence in reduction of the dissolved oxygen to such an extent as to interfere with major fish life, this is of course indeterminable. There is no specification as to what
3347 is major fish life; furthermore we do not know the effect of the exhaustion of dissolved oxygen on fish life, that is, definitely and scientifically. The inference is, however, that there is a possibility that, although this may not affect what may be termed major fish life, it may affect largely minor fish life.

Q. Mr. Horton, how far will the fulfillment of the conditions or specifications under this second item in the stipulation protect the State of New York?

A. The stipulations, assuming them to be fulfilled, the four following stipulations in my opinion, would fairly satisfactorily protect the State of New York. That there will be absence of visible suspended particles and so forth; that there will be absence of odors and so forth; that there will be absence of color and grease and so forth; that there will be no injury to the public health. The other specifications would be less satisfactory. That is, the absence of

deposits objectionable to the Secretary of War, and there is no guarantee to New York State against objectionable deposits. There might also be other objections to New York State than those objectionable to the United States. It is my understanding that deposits affecting the United States would probably be confined to the main channel and with less reference to sanitation, whereas these deposits that would be more vital to the State of New York might occur outside of the channel of the harbor and bay in shallow places and thus materially affect the comfort and health of the people of New York, first, through infection or menace or danger to the oyster industry, and nuisances which may arise from septic action, and filling up shallow places, the deposits being more likely to fill these places, than the channels. Here, deposite may occur from these suspended materials delivered from the sewage.

Q. Now, as to the absence of injurious effects on the property of the United States, how would that insure absence of injury
3348 to the property of the citizens of the State of New York,

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for Defendants.

A. There is no guarantee to the State of New York.

Mr. Riker: I object to the opinion of this witness as to the legal effect of the instrument.

Mr. O'Sullivan: I am inquiring, Mr. Riker, as to the facts.

Mr. Riker: I am putting my objections to your questions on the record, that is all.

Q. You may proceed?

A. There is no guarantee to the State of New York with regard to any damage to it, in this respect. This provision suggests the possibility of certain damages not provided for in sections of the stipulation which might affect New York State, such as the injury to paint, the use of water for deck purposes, for washing decks and the use of the water for incidental purposes such as condenser water, ice refrigeration and cooling purposes, fish cleaning purposes and so forth. There also may be a deleterious effect on the corrosion of iron and from the acids or chemicals that may be in the sewage and the trade waste, which are mixed with it.

The other stipulations which would be unsatisfactory would be the absence of reduction of dissolved oxygen, as to its interference with major fish life. This test in my opinion is a useless one to protect the interests of New York State. Major fish life is not defined. We do not know the effect of sewage on such life sufficiently well or definitely to use it as an index of damage from pollution. There is no way of telling statistically or otherwise whether interference with fish life, in the cases used as criteria were due
3349 to deficient supply of oxygen or other causes. We could not trace definitely any deteriorating effect of the Passaic Valley sewers in distinction or counter distinction from other sewer

pollution in New York Harbor, and we might have offensive conditions near the outfall, but when the sewage is dispersed and diluted the oxygen content might not be reduced so low as to interfere with such life. Furthermore, there is no guarantee that minor fish life would not be affected. If it were, then this will be one more injury to waters of the harbor, due to the Passaic Valley project.

Q. As to the practicability of proving any of these injuries, as an engineer what is your conclusion in that respect relative to the stipulations.

Mr. Riker: The question is objected to on the ground that it is not a matter of injury as to whether or not the violation of the stipulation with the United States can be proved or not. It is only what is the expressed intention of the State of New Jersey and the Passaic Valley sewerage Commissioners for carrying it out.

The Commissioner: Note the objection of Counsel for Defendants.

A. It is my opinion that some of the provisions are partially enforceable, such as numbers 1 and 2, 1—that there will be absence in New York Bay of visible suspended particles, and 2, that there will be practical absence on the surface of the water, of any grease or color and so forth. That is the pollution will be so intense at or near the dispersion field generally, as to show unmistakably the source of the trouble by contrast with other and less polluted waters adjacent. At other places, however, these conditions would
3350 be so apparent by contrast, that differentiation would be more difficult, if not impossible.

Other provisions, such as 2 and 6, are unsatisfactory to the State of New York in regard to the enforcement, on the ground that New York State is neither a party or a judge in reference to those stipulations, owing to the provision in the contract stating that the Secretary of War is the sole judge and he would have the same difficulty to substantiate his position, if the conditions were decided by him to be objectionable. The Secretary of War would find it impossible to indentify the Passaic Valley sewage or the cause of the deposits and injurious effects. These deposits would be slow and progressive and due partly to other causes and hence it would be difficult to differentiate it from the other factors.

Further, the State of New York is given no access to the works or outlet, to the purification works or the outlets, or opportunity to determine as to the fulfillment or occurrence of the damages or objectionable conditions which may affect the United States Government.

The remaining provisions, 3, 5, and 7, are practically unenforceable. First with respect to the nuisance from odors, for, although odors directly over the dispersion area might be so strong as to preclude any question as to their source, these odors might be less intense at other points more distant, where it might be difficult to fasten responsibility upon the Passaic Valley Sewer, on account of the pollution from other sources, and the overshadowing of these

odors, from other sources, such as the plants at Constable Hook. They would be unenforceable owing to the difficulty or indefiniteness of the term "putrefaction of organic matter." We have no accepted meaning of the term, that is, scientific meaning. There might be odors due to other matters, such as manufacturing wastes, gas and tar wastes and so forth mixed with the sewage.

3351 With respect to the injury to health, the danger will be largely remote, through the effect on bathing, shell fish, drift wood, washing decks with the water and so forth. The dangers are of a nature difficult to prove by statistics and the channels of infection are difficult to trace though we know they exist, such as from oyster epidemics of typhoid fever, epidemics of eye diseases among children who use the swimming pools; general principles and isolation of disease germs from water; transmission from handling and digging oysters; studies of fly transmission due to the sewage pollution and the general prin-ples of disease transmission, and by analogy. Again, being at a distance, it is absolutely impossible to identify the dangers, as due to the Passaic Valley sewer. There are other sewers of course, discharging sewage, and they have a tendency to overshadow the effects of the Passaic Valley sewer and make it thus more difficult to differentiate.

Q. Now, as to the test applied to the reduction of dissolved oxygen relative to major fish life, have you considered that, and if so, state what your conclusions are relative to that portion of the stipulation?

A. That is relatively unenforceable on the ground that the term "major fish life" is indefinite. We know little about the effect of dissolved oxygen on fish life, and it is impracticable to prove that diseases or injury to fish life are due to lack of dissolved oxygen, or whether they are due to some other cause.

Other sections of the contract or stipulation are equally objectionable, in so far as there is no opportunity to inspect the outfall works. This is important in my opinion, in order to determine how far, so far as it is possible to do it, the provisions of the contract are being fulfilled.

3352 Mr. Riker: I move to strike that testimony out as the instrument speaks for itself, and the statement of the witness is directly contrary to the instrument itself.

The Commissioner: Note the motion of Counsel for Defendants.

Q. Proceed.

A. This is important also to secure information to be used as the basis of complaint or appeal to or from the Secretary of War.

Mr. Riker: I suggest, Doctor, that your witness examine this stipulation before he goes on record as to the contents of this instrument. It is an unwise thing for him to do, to swear to that, because it is not so. It provides that the United States Government shall have an inspector there all the time.

Mr. O'Sullivan: In the stipulation?

Mr. Riker: It certainly does.

The Witness: I stated that this was important in order that we

may determine the fulfillment of the provisions of the contract; that we may secure information as a basis for that, to use as a basis of complaint or appeal to or from the decision of the Secretary of War, and to observe the variations and progressive changes in conditions from year to year that will take place in the harbor waters due to the discharge of the sewage into it.

Furthermore, since the Secretary of War appears to be the principal judge in this stipulation, at least the only party interested, or in sympathy with the State of New York's interest, there is no guarantee first that he would be interested in matters which the State of New York is most interested in, and secondly that his standards would be at all satisfactory to the People of New York, or in their opinion, to their best interests. Thirdly, that he could or would determine the effective fulfillment of this contract. Fourth, that even if he did decide that additional lawful works were neces-
3353 sary, that his decision would be final and binding on New Jersey to construct these additional works. Fifth, that much time might be lost after such notice before such work- could be constructed. Sixth, that not knowing what these works are, and there being no intimation in the contract as to their nature, there is no evidence or security that these additional lawful works would remove any objectionable conditions found to exist.

Q. Mr. Horton, in your opinion, is it necessary or desirable or economical to dispose of sewage in accordance with the plans of the Passaic Valley Trunk Sewer project as provided in this stipulation.

Mr. Riker: The question is objected to as being entirely immaterial as to what this witness' opinion is on that subject.

The Commissioner: Note the objection of Counsel for Defendants.

A. In my opinion the project such as is proposed is not necessary, nor is it a desirable or economical way to dispose of the Passaic Valley Sewage. It is not necessary since there are other and more efficient methods, perfectly feasible and possibly less expensive, first, such as screenings and more efficient settling with disinfection; second, screening and settling followed by filtration or purification in coarse grained filters, such as contact beds or sprinkling filters. Furthermore these more effective works could be installed on the Newark Meadows or elsewhere, with a discharge either into New York Harbor or into Newark Bay. Furthermore, there might be individual or small groups of joint disposal plants for the different communities of the Passaic Valley District of a type such as above referred to, situated at different points within the Passaic Valley District, with discharges into the Passaic River or its tributaries.

3354 Q. After the studies which you have pursued during the period that you have given, and from the access that you have had to the various data and exhibits accumulated in this case, what in your opinion, Mr. Horton, would be the result of the discharge of the quantity of sewage through the Passaic Valley Trunk Sewer outfall at a point in the Upper Bay approximately at Robbins Reef.

Mr. Riker: The question is objected to on the ground that it is a hypothetical question, the basis of which does not appear to be proved in this case.

The Commissioner: Note the objection of Counsel for Defendants.

A. It is my opinion that there would be a nuisance created, and that there would be a menace to health created, the nuisance being more intense in the immediate vicinity of the outfall, but extending a considerable distance beyond it and carried to quite distant shores, a nuisance caused by discoloration of the water, offensive odors, deposits, diminution of the dissolved oxygen in the water and then there will be a menace to health from infection received from people using the bathing beaches and from infected material such as drift-wood, from the eating of shell fish, and there would be an indirect menace to health from the reduction of the vital resistance resulting from offensive odors, and objectionable conditions from the sewage as it will appear.

Mr. O'Sullivan: Your witness.

Cross-examination by Mr. Riker:

Q. Mr. Horton, when did you sever your connection with Messrs. Hering & Fuller?

A. In 1906.

Q. Why did you sever it?

A. To accept the position as Chief Engineer of the State Department of Health.

Q. Do you recognize your former employers as men of any standing in your profession?

A. I do.

3355 Q. Do you know that they have approved of this stipulation?

A. I did not.

Q. If they have approved of it, you are still of your own opinion that you have expressed here that it is faulty in every respect?

A. I am still of the opinion that I have expressed; yes, sir.

Q. Now, Mr. Horton, if all the sewage of the City of New York, including all of the Boroughs, were treated so as to produce an effluent corresponding with that which is described or guaranteed in the stipulation in question, what effect do you think would be produced in the harbor of New York?

A. I have just testified that what is stipulated cannot be accomplished. If you mean assuming that to be correct?

Q. That is what I said?

A. I wanted to be perfectly sure before answering.

Q. That is what I said.

(Question repeated by the stenographer.)

A. I think the Public health—I have already testified in regard to that partially.

Q. I want you to answer the question if you can. If you cannot you can say so.

Mr. O'Sullivan: Do you understand the question?
The Witness: Not thoroughly.
(Question repeated by the stenographer.)

A. My opinion is that if the sewage of these Boroughs in the City of New York were treated in such a way as to produce an effluent such as would meet the stipulations guaranteed, that the City of New York—will you repeat the question again?

(Question repeated by the stenographer.)

A. (Continuing:) *A.* I think the sewage would be sufficiently treated to prevent largely a nuisance, and would be substantially free from a menace to health.

3356 Q. And you think the same results produced in the proposed discharge from the Passaic Valley Sewer will create a nuisance in the harbor, do you?

A. No, sir. I will have to go back to that question relative to the specified sewage treatment and the guaranteed results. I have just pointed out that the sewage works will not accomplish the guaranteed results.

Q. I do not care about that. I want you now to keep your mind fixed on the guaranteed results. You have said now that if an effluent from the New York sewage was produced so as to result in the guaranteed results, there would be no nuisance. Why do you have to refer to those?

A. Because I have already answered that one.

Q. You must confine yourself to your written notes in order to answer on cross examination?

Mr. O'Sullivan: I object to the question as being clearly indefinite, the word "results" being so comprehensive as to include both the results which would come from the plant itself and the guaranteed results which could never be accomplished.

The Commissioner: Note the objection of Counsel for Complainants.

Q. Can you answer the question? If you cannot answer it, say so?

A. I cannot answer that question.

Mr. Riker: Very well, put it on the record, he cannot answer it.

Q. Can an effluent in your judgment be produced from the sewage of the Passaic Valley which will, when discharged in New York Harbor produce the guaranteed results as they are stated in the stipulation?

A. May I refer to the stipulation?

Q. Yes.

A. Yes, sir.

Q. And these alternative methods that you have testified to, toward the end of your direct examination, will any or all of them produce an effluent of the character that is guaranteed?

3357 A. Some of them.

Q. It is your opinion that the specific processes which are defined in the stipulation will not produce the effluent guaranteed?

A. Substantially I so say.

Q. Now, if you add some of the processes which you have testified to, as an alternative, will the guaranteed effluent be produced, in your opinion?

A. Substantially.

Q. Have you anything in your mind which indicates to your mind that these processes are unlawful?

A. It is a legal matter that I have not touched upon.

Q. Now, Mr. Horton, assuming that the instrument which has been spoken of as the stipulation is not signed by the State of New York and is not made with the State of New York at all, but simply expresses the intent of the State of New Jersey and the Passaic Valley Sewerage Commissioners, if that intent is carried out in the effluent guaranteed, will there be a nuisance produced in the Harbor of New York?

A. I do not know what the intent is.

Q. You do not know what the intent is—you cannot take the intent from the stipulation?

Mr. O'Sullivan: I object to the question. That is getting into the region of metaphysics.

The Commissioner: Note the objection of Counsel for Complainants.

Mr. Riker: We have had all sorts of stuff, metaphysics, and law and all sorts of stuff, and now I am getting a little metaphysics from this witness.

Mr. O'Sullivan: I also object to that part of Counsel's statement that this witness has dealt with any legal proposition.

The Commissioner: Note the objection of Counsel for the Complainants.

3358 Mr. O'Sullivan: I also object to the question on the ground that it is ambiguous, metaphysical and so extremely hypothetical as to take us into the regions of metaphysics.

The Commissioner: Note the objection of Counsel for Complainants.

A. Assuming that the intent of the Passaic Valley Sewerage Commissioners and the Secretary of War or the Government, in this case, is to carry out the guaranteed results, I think there will be very little nuisance and very little menace to health. I specified and explained that more in detail in my former reply.

Q. Well, now, Mr. Horton, are you familiar at all with the character of the property of the United States Government in the Harbor of New York?

A. Except as I see it passing by. I am not familiar with it all.

Q. Some of it?

A. You mean the Government property, the army fort there and the lighthouses? I have seen them, yes, sir.

Q. You are testifying as to that part of the stipulation which deals with the Government property, don't you know what it is?

A. Governor's Island and the fort.

Q. What else?

A. Robbins Reef Light, those are the principal ones I had in mind.

Q. You know the Brooklyn Navy Yard?

A. Yes.

Q. Do you know Ellis Island?

A. Yes.

Q. And if there is no injury produced on the property of the Government in the harbor by this discharge, what property do you think will be injured by it?

A. I stated because you may have a lot of property that is not owned by the Government and New Jersey and the part that is owned by the State of New York might be largely damaged from various sources.

Q. What kind of property would be damaged in your judgment if the property of the United States is not damaged?

3359 A. Why the shipping industry and the beaches and wharves.

Q. What else, anything else?

A. Those are the principal ones I can think of.

Q. You spoke of the boats?

A. I said shipping. I mean all the merchant marine, vessels.

Q. You mean the vessels themselves?

A. The vessels themselves, yes, also from the water used on the vessels that may be taken from the waters.

Q. Are there any United States war vessels in the harbor at any time?

A. I guess there are, for a short time.

Q. Are there any at the Brooklyn Navy Yard?

A. I think so.

Q. You have seen them there?

A. Yes, sir.

Q. Well, would they be injured if the other vessels which you have in mind were injured?

A. Injured from what; they are injured already probably.

Q. From the sewage?

A. From the sewage discharged from the Passaic Valley?

Q. Yes.

A. Indirectly, yes, sir.

Q. If the stipulation is complied with and there is no injury to property of the United States, will there be any injury in your judgment to other like property in the Harbor?

A. Not if the stipulation—that part of the stipulation. We are coming back to that same question.

Q. The stipulation provides that there shall be no injury to the property of the United States in the harbor of New York, that is in general terms, from the sewage discharged from the Passaic Valley Sewer. Now, I am asking you if the property of the United States, ships and war vessels of different sorts, if they are not injured, whether other shipping of like character will be injured?

A. They might be because they are different types of vessels, a good many of them.

Q. In what in your judgment might the injury to these
3360 other vessels consist, which would not apply to the United States vessels?

A. I cannot think of any just now. I say there might be. I think I could think up some.

Q. Are there any wharves or piers belonging to the United States in the harbor of New York that you know of?

A. Wharves and piers?

Q. Wharves or piers?

A. I do not know what you refer to by those particular ones, no, sir.

Q. Are there any wharves on Ellis Island?

A. You referred to the Navy Yard. Assuming there are wharves around this place.

Q. I am not assuming anything. I am asking you whether there are any wharves or piers?

A. Yes.

Q. So that they would be injured from this discharge in your judgment?

A. Yes.

Q. Well, now, assuming that the stipulation is carried out and the property of the United States is not injured, and that the wharves and piers of the United States Government in the harbor are not injured, what injury in your opinion is going to occur to other wharves and piers in the harbor from this sewage?

A. These piers I have just testified to, those piers and vessels will be injured by the sewage from the Passaic Valley sewer, if you are now asking me a hypothetical question——

Q. I am asking you to assume that one of the stipulations as to the guaranteed results is actually carried into effect?

A. There will be no damage. There are two or three stipulations referring to the Government.

Q. There is only one regarding the property of the United States?

A. The sixth. I do not know what the United States will consider is injurious to them.

3361 Q. Will you read the stipulation and see whether it says the United States shall consider itself. I think it says there shall be no injury.

A. It says "injurious effect".

Q. Well, injurious effect then. You think that is different from injury?

A. There might be confusion.

Q. So you distinguish between injury and injurious effect?

A. I will accept this, that they are substantially the same. We will assume that they are the same.

Q. I want to know what your opinion is as to what classes of property will be injured by the discharge of the Passaic Valley sewage as proposed, in case the stipulation is carried out and no injurious results occur to the property of the United States in the harbor?

A. Well, the bathing beaches will be affected, that is one of them. The oyster industry will be affected. There may be a number of

other things that are not owned by the United States Government that are owned by the State of New York.

Q. They in your opinion may be sufficiently different from the property of the United States in the harbor so that injury might result to that property when it would not result to the property of the United States?

A. Very materially with respect to those two things just mentioned.

Q. Is there anything else that you can think of?

A. I take this as not a sanitary question, this injurious effect. It refers more to the injury to property, property injury. Of course, if it means any injury of any kind, we have got to go through this thing with a fine tooth comb.

Q. You have undertaken to interpret it?

A. I give you my opinion and my interpretation of how I accept this thing.

Q. You mean there would be injury to property, don't you?

A. I mean large injury to property, yes.

Q. Property situated in New York Harbor?

A. Property situated in the vicinity of New York, yes, take the bathing pavilions around here.

3362 Q. And the shell fish, anything else?

A. The bathing features.

Q. Anything else?

A. You are after a differentiation between the Government and the State?

Q. I want to know from what other things there would be injury that you can refer to?

A. Those are the ones that I think of just now.

Q. Now what will be the injury to the shell fish?

A. The shell fish will be injured by infection, by infected material that will be carried to them by the tides and winds.

Q. And they will become unfit to eat; is that the trouble with them?

A. Ultimately, yes.

Q. If they are not unfit to eat, what injury will be done to them in your opinion?

A. It may affect the industry. They may be unfit to eat, but people may eat them. From a hygienic standpoint, it may injure them by settling suspended matters on them and it may make them objectionable in appearance and thus destroy the industrial value.

Q. Would that constitute in your opinion a private nuisance or not?

A. That would be quasi private or public.

Q. Will you assume in addition to stipulation No. 6, Stipulation No. 5 in connection with it, and assume it is carried into effect that there will be no injury to public health occassioned by the discharge of said sewer into the harbor in the manner proposed, and no public or private nuisance created thereby. Now, assuming those two things are carried out, what injurious result do you anticipate?

A. I do not anticipate any substantial injury.

Q. And I think you have said, but I will take the liberty of ask-

ing it over again, that there might be, could be a treatment of the sewage of the Passaic Valley, which would result in an effluent which would make the results which are guaranteed?

A. Substantially so, yes, sir.

3363 Mr. Riker: I think that is all.

Redirect examination by Mr. O'Sullivan:

Q. Do you regard bathing beaches as property, and the paraphernalia that goes with bathing?

A. I have considered that as property, because I understand that I am taking it in a broad sense. A bathing beach is property. There is something there that is of value to the people or the state.

Q. Do you regard shell fish beds as property?

A. Yes, sir, in that general sense.

Q. Do you regard the paint on ships and boats as property.

A. I do.

Q. Now, if there is no injury to property, will there be any injury suffered by the property?

Mr. Riker: That is the logical and necessary conclusion, that if the stipulation is complied with, there will be none.

Q. Is it feasible for the plant described in the stipulation to produce the results guaranteed?

A. No, impossible I think.

Q. Is it feasible to produce these results short of prohibitive expense for such a large volume of sewage?

A. Using prohibitory in a broad sense, it would be impossible to. I would have to know what you mean by prohibitory. You mean very large expense?

Q. I mean if the expense would be so great as to be a very serious and unlikely burden to be assumed by communities?

A. Yes. It would cost considerable more than the present proposed method of treatment.

Recross-examination by Mr. Riker:

Q. Now, Mr. Horton, do you think that an effluent of less purity could safely be discharged into Newark Bay?

A. Safely, in regard to what?

Q. Safely as regards the inhabitants about Newark Bay?

A. Why, no, I do not think so. That is you mean the

3364 plant as proposed here?

Q. No, I do not?

A. You mean less than that plant?

Q. Should anything less than the effluent as guaranteed from a sanitary standpoint of view be discharged?

A. I do not think any less than that could be discharged into Newark Bay.

Q. Or the Passaic River?

A. Certainly not less.

Q. Or the tributaries of the Passaic River?

A. No,—they have gone down pretty near to the limit.

Q. Do you think the dividing up of this sewage and the establishment of separate disposal plants would be more economical than one disposal plant on the meadows?

A. I could not answer for that.

Q. Why can't you, that is in your line?

A. That depends on so many local conditions. It is absolutely impossible to answer that. I have that question put to me a dozen times a week almost and I simply cannot answer it without definite local information and some local calculations.

Q. You have some definite information?

A. I never estimated the individual plants along the Passaic River.

Q. You know the conditions along the Passaic River?

A. Yes, sir.

Q. You have studied them for some number of years?

A. Not the individual ones. Now we are talking about disposal. That is a very specific study.

Q. I want to know if you can express an opinion on it. If you can't of course do not do so, as to the relative economy of establishing separate disposal plants for all the municipalities in the Passaic Valley or taking the sewage to the Newark Meadows and disposing of it at one plant?

A. Assuming the same degree of purification it is impossible to tell whether individual plants would be cheaper than a joint plant or not, because it would depend on so many factors, such as the distances of these various outlets from the respective individual
3365 municipalities, the topography, the character of the soil, the type of plant, in order to produce the same effluent.

Q. You think, if there is any question, speaking generally, it is more economical to operate a large plant than a number of small ones?

A. It frequently is so, but not with a sewage disposal through a very long trunk sewer with a long expensive outlet.

Q. Assuming not a long outlet from the disposal works at all, but a comparatively short one. Do you think that one general plant is likely to be more economical or less so than a number of individual ones?

A. That is quite difficult to state owing to the fact that the short plant may be under very difficult methods of construction. If it is under water, or there may be conditions that may make it very difficult and expensive.

Q. You are familiar with the conditions around Newark. Do you know of any place where such a plant that you have in a general way described, could be located except on the Newark meadows?

A. I think there might be groups of them. It could be disposed of in other places.

Q. Take the City of Newark by itself as separate,—do you know of any place where there could be a disposal plant established except on the Newark Meadows?

A. I should not think of placing it any other place. That is the disposal plant such as I referred to, something beyond mere sedimentation, something like filter beds, contact beds.

Q. You know the conditions of the Passaic River about Newark?

A. Yes.

Q. In your opinion are they or are they not intolerable?

A. Yes.

Q. And the sewage, the disposal of it, in your opinion, should be taken out of the river?

A. Yes.

2366 Q. Do you know how it could be treated or where it could be treated by a disposal plant other than in the general location of the disposal plant as proposed by the Passaic Valley Sewerage Commissioners?

A. It could be carried south or could be pumped almost anywhere.

Q. Do you think that it would be desirable to do that?

A. The City of Newark may value those meadows a great deal more than I would the pipe line extending from ten miles away. Of course, that may be water front, you know.

Q. Do you think your suggestion of separate systems of disposal would be prohibitive in expense to establish in the Passaic Valley Sewerage District?

A. I do not think so.

Q. But you think the general system is practically prohibitive, do you?

A. Now you are talking about something different than I had in mind. Are we comparing these as having the same effluent, or comparing one a purified effluent, such as I think ought to be put in there?

Q. I ask you whether an effluent less pure than that guaranteed in the stipulation——

A. I put a limit on it. I said at least that. If you want to get a higher purification, a drinking water standard,——

Q. You were asked as to the prohibitive character and cost of the production of an effluent such as is guaranteed in the stipulation?

A. Yes.

Q. And you said in your judgment that it would be so burdensome to the municipalities that it would be practically prohibitive?

A. No, I did not say that. I said it would cost a good deal more than the plant proposed, the scheme of disposal. That is what I said.

Q. But do not you remember, you were asked whether or not in your opinion it would be prohibitive?

A. Then I asked what you meant by prohibitive, and I got the understanding that we changed our answers a little from the former ones.

2367 Q. What would be in your judgment the financial aspect of the adoption of the necessary plant and works to produce the guaranteed results?

A. I think it would cost considerably more than the proposed plant. How much more I could not tell you and I gave a reason for that.

Q. Don't you remember you were asked whether in your opinion it would be practically prohibitive?

A. I remember your asking the question in regard to prohibitory.

Q. Do you think it would be extremely burdensome on the municipality?

A. To have individual plants?

Q. No, to have one plant which would produce the guaranteed effluent?

—. According to the value that I put on sanitation, I do not think that it would be prohibitive, absolutely prohibitive, using the term strictly.

Q. Do you think that it would be very burdensome?

A. Think that it would be burdensome. It is always burdensome for municipalities to dispose of sewage. It costs money.

Q. And do you think that it would be burdensome for the individual municipalities to establish separate plants and operate them?

A. I think it would be somewhat burdensome, financially burdensome at least to some of them.

Q. Would it be in your opinion more or less financially burdensome than to join in the general purification plant?

A. That I cannot tell you because I do not know the relative cost of the two. You would have to have pretty good purification, and the different plants would vary in their types and the local conditions would vary considerably, and I have never seen any estimate of cost of the individual disposal plants, and I would find it a very difficult matter to give a snap shot judgment in regard to it.

Q. I think you will agree, will you not, that it is necessary to purify the Passaic River from sewage at the present time?

3368 A. No question about that.

Q. And I think you will agree, will you not that that purification must be accomplished either by diverting the sewage and discharging it beyond the limits of the Passaic River or by purifying it so that the effluent is no longer injurious to the river or bay water?

A. Yes.

Q. And if the latter scheme is adopted, I think you will agree, will you not, that whether it is by individual plants or by a general plant, it will be burdensome to the municipality from a financial point of view?

A. You are not asking for any comparison. I think absolutely it would be burdensome in the way I speak of that it would cost considerable money.

Q. And I think that you have said that you were not prepared to give an expression of opinion as to the relative burden?

A. No.

Q. You were asked in regard to bathing beaches being property and I want to know whether in your opinion that property value of bathing beaches will not be injured, if injured at all, from sewage, through the effect on the health of those that use them?

A. No, it might be damaged in another way, it might be damaged from the sediment getting down there. The suspended matters may drift over with the current.

Q. If there were no suspended matters?

A. I have said that there would be suspended matters.

Q. The difficulty with you, Mr. Horton, is that you are prepared to state that in your opinion "there ain't going to be no core"?

A. You have already specified the plant that you propose to put there. I do not understand that there is to be any other.

3369 Q. In your testimony you are assuming that no other processes or devices will be introduced into the purification of this sewage?

A. I do not say that. I do not think that I said that.

Q. Are you assuming it?

A. That they would not in the future?

Q. Yes.

A. Why, the contracts specify that there would be lawful additional improvements in the future.

Q. In the future?

A. If necessary and I pointed out the difficulty of showing when it was necessary.

Q. Why do you make it in the future?

A. It is proposed to put in a certain plant, and if that does not accomplish certain results then they will do something else.

Q. You ought not to testify to the contents of a written instrument without having it before you. Where do you find that, if they will not do it?

A. Substantially I will put it that way.

Q. Just point out what you refer to. I think it is the last clause of the second general paragraph?

A. I said substantially because my reason for it is you cannot tell anything about that until you get the plant constructed. They have got to construct it first before any lawful additional work would be installed, wouldn't they?

Q. Well, Mr. Horton, you recognize the fact that the agreement is in the disjunctive, don't you, that either through compliance with the requirements of the immediately preceding paragraphs or through requisite lawful additional arrangements?

A. Yes, I see that.

Q. That is the assumption that you are basing your testimony on?

3370 A. My assumption is they are to put in the works, and the meaning of that clause is that if the works do not accomplish the results they will make it so by additional lawful works.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Horton, I hand you Complainants' Exhibit No. 135 and call your attention to the paragraph marked Second on page 3, and ask if you as an engineer had to construct the plant described

there, whether you would follow the general description of the plant given in the section preceding that paragraph?

A. I would not devise a plant such as is described.

Q. Why not?

A. Because I do not think it would accomplish those results.

Q. Under that stipulation you would be expected first to try that plant, to see if it would yield those results, as an engineer?

Mr. Riker: The question is objected to on the ground that it does not appear by whom he would be expected to do it, and it is immaterial anyway.

The Commissioner: Note the objection of Counsel for Defendants.

A. I do not understand the question, Doctor.

Q. If you were called in as an engineer to design the plant as described there, I ask if you would first design that plant in accord with the terms of the stipulation and see whether or not it yielded the effluent that was guaranteed before you would add any additional plant, or additional means of securing that effluent?

A. Well, if I had a free rein to do what I knew was proper in designing the plant I should design a plant more efficient than that described here.

3371 Q. If you had to follow that stipulation and take it as your guide, whether you would feel bound to first erect a plant such as is described there, before you would think of argumenting the process of that plant?

A. It is pretty hard for me to say what I would do. That is rather a hard question, as to whether you would design a plant which you thought might possibly in a pinch perform the results. Now, I do not think that I would design a plant such as is described there, but as to whether I would put in something that I thought would be less efficient and try it out before I tried something else—I do not think that I should do that.

Q. Mr. Horton, I now direct your attention to what I now propose to read from Complainants' Exhibit No. 135, page 3, the paragraph marked Second. "The Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system at all times the following results shall be secured, either through compliance with the requirements of the immediately preceding paragraphs or through requisite lawful additional arrangements." I now ask you as an engineer whether it would be proper to erect that plant and see if it yielded these guaranteed conditions of the effluent, before applying any additional arrangements to secure it?

A. I understand the situation a little better, and I would because it specifically states in that paragraph,—given this as a basis for my work and my design, I would feel in duty bound to do that.

Q. Mr. Riker asked you some questions relative to the burdensome features of separate disposal systems and this trunk sewer project. I ask you if there are not to your knowledge communities along the Passaic River that have made computations along these

lines and determined for themselves that it would be less burden-
some to put in a separate sewage disposal system than to join
3372 as a party to the trunk sewer project?

A. I know of one case, yes, it is of my general knowledge that there are a number of cases of that kind, more particularly, I think Paterson.

Q. Montclair, or the Oranges?

A. I have no direct knowledge. I have been advised by people who I think know, that Montclair has developed a scheme for sewage disposal in an individual plant located somewhere in the vicinity of Glen Ridge.

Q. And was that separate disposal system to be installed on the basis of efficiency and economy as against the Passaic Valley Trunk sewer project?

A. I do not know about that.

Recross-examination by Mr. Riker:

Q. Mr. Horton, don't you know that Paterson has entered into the Passaic Valley agreement?

A. It may have lately, I do not know.

Q. You do not know whether it has or not?

A. I am not positive, no, sir, and I refer to Paterson more with reference to the study made by Hazen with the conclusion that Paterson could more economically dispose of sewage on the Hackensack meadows that it could in the Passaic Valley District.

Q. And is that all your understanding as to Mr. Hazen's report on Paterson?

A. That was one of the options. That was one of the optional schemes shown, to carry it over there.

Q. You do not know whether he recommended that Paterson join in the Passaic Valley project?

A. I do not know whether Hazen recommended that. I do not remember.

Mr. O'Sullivan: I have got the report in which he said that if any purification scheme were adopted, it would be more economical to go into a separate disposal system.

Q. You have been asked what you would do as an engineer under certain conditions. Now, as an engineer if you were re-
quired to construct a plant so that when operated it would
3373 be operated in accordance with certain requirements, which
are the requirements A and B and C of the stipulations, a copy of which report you have before you, I suppose that you could build a plant which would be operated in accordance with those stipulations?

A. If that were all.

Q. Whether it is all, or whether it is not all. If your order was to construct a plant which should be operated in accordance with A, B and C would you build such a plant?

A. I could not, for the reason that some of those are indefinite,

it is not specific as to what it is. In fact I have assumed in some of my calculations, I have had to assume dimensions here, but generally speaking, if I were ordered to build a plant and it were definitely stated and I accepted the order, I would go ahead and build it.

Q. And if in addition to that you were ordered to produce a plant which should include the features in A, B and C, which plant would discharge an effluent of the character indicated by paragraphs 1, 2, 3, 4, 5, 6, and 7 in parenthesis under the second section, then you would do that?

A. I would be up against it. I would be pretty hard up against it.

Q. Why?

A. Because I would say it was impracticable to do it.

Q. Could you not add to A, B, and C, features that would produce the 1, 2, 3, 4, 5, 6, 7?

A. Then I would not be constructing under A, B and C.

Q. Would you necessarily have to omit some of the things specified in A, B and C?

A. I would have to add considerably more, and perhaps modify at the outset.

Q. You could by adding to A, B and C, you could produce 1, 2, 3, 4, 5, 6, 7?

3374 A. No, not necessarily, because A, B and C involve structures, outlets in place, and if I were taking it up de novo I might not adopt that same kind of a scheme at all.

Q. That is a question of efficiency and economy?

A. Somewhat, possibly.

Q. Is it not possible to add features to A, B and C?

A. Generally I think you could have screening and sedimentation and add additional works and produce an effluent which would produce the results guaranteed under 1, 2, 3, 4, 5, 6.

Q. Now, if you were directed and accepted the job of putting in a plant which would embrace A, B and C and would produce 1, 2, 3, 4, 5, 6, 7, would you or would you not put in the additional features necessary, as an engineer?

A. No, I do not think that I should on account of the section under Second, under compliance. I would feel that that meant that you would be expected to try something whether you knew it was right or not and see whether it worked.

Q. I am assuming that you are directed to build a plant which would involve A, B and C under the first general section and would produce the results 1, 2, 3, 4, 5, 6, 7, under the second general section. I am now asking whether you would or would not add the additional features to A, B and C, necessary to produce 1, 2, 3, 4, 5, 6, 7, under the second general section?

A. I presumably would not until after I had constructed A, B and C.

Q. You would not do it, believing from your professional experience that A, B and C would not produce the guaranteed re-

sults, your mean to say that you would not add the additional features, if you were directed to produce the guaranteed results?

A. If I were directed under those conditions I would be directed to do so regardless of my opinion whether they would or would not. You cannot get away from that ethical question involved there.

3375 Q. It is purely a question of professional opinion whether or not A, B and C will produce 1, 2, 3, 4, 5, 6, 7?

A. I say they will not.

Q. Then if you were required to produce 1, 2, 3, 4, 5, 6, 7, you would have to add additional features?

A. If I was going to accomplish that and undertook the construction of the work to accomplish that, I would have done that in the beginning. That is a little different than if I were given a free rein. When it says they shall be accomplished either through compliance with the requirements of the immediately preceding paragraphs or by requisite lawful additions—that to my mind intimates that it was the opinion of the person giving me the orders that A, B and C would do the work. He simply asked me as a constructing engineer to come in and construct those works and presumably I would go ahead and do it if I accepted the job, regardless of sanitary consequences.

Q. Your trouble is that you do not agree with the proposition that A, B and C will produce the result?

A. I have stated that A, B and C will not produce 1, 2, 3, 4, 5, 6, 7.

Q. In your opinion?

A. Yes, sir.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Horton, can the sewage of 37 municipalities and towns be treated more efficiently by the separate sewage disposal system or in concentrated form where it is collected and has become stale?

Mr. Riker: The question is objected to on the ground that the question is hypothetical and is not based on any facts proved in this case.

The Commissioner: Note the objection of Counsel for Defendants.

A. I think it is very difficult to say, to give a definite answer to that question. My opinion is generally that it is better to take the sewage and treat it when it is more fresh than when it
3376 is in a stale and septic condition and it is frequently more economical to treat it individually than it is the other way, although with a very long trunk sewer the opposite may obtain.

Mr. O'Sullivan: That is all.

Mr. Riker: That is all.

Mr. O'Sullivan: Complainants rest.

Adjourned subject to the call of the Commissioner.

3377 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Testimony on Behalf of Defendants.

Taking of testimony at the office of Messrs. Riker & Riker, Newark, N. J., Friday, December 27th, 1912.

Before James D. Maher, Esquire, Commissioner.

Appearances:

Thomas Carmody, Esquire, Attorney General of the State of New York; William A. McQuaid, Esq., Deputy Attorney General; Dr. William J. O'Sullivan, Special Counsel, for the People of the State of New York Complainants.

Edmund Wilson, Esq., Attorney General of the State of New Jersey; Robert H. McCarter, Esq., of Counsel for the State of New Jersey; Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Doctor O'Sullivan: Mr. Commissioner, before the defendants introduce testimony I want to have two substitute exhibits put in; when I put in exhibit #157 I had only the advance sheets and I should like to offer the perfected copy itself in evidence, I have that perfected copy here properly certified and I ask that it be marked Complainants' Exhibit #157 in place of the temporary copy
3378 already offered.

Mr. Riker: Subject to the same objection made to the offer of the advance sheets.

The Commissioner: Yes, the objection of defendants' counsel is noted.

(The perfected copy produced by Dr. O'Sullivan was then marked Complainants' Exhibit #157.)

Dr. O'Sullivan: I also offered in evidence what purported to be the stipulation entered into between the United States Government and the State of New York and the Bronx Valley Sewerage Commission, which was marked Complainants' Exhibit #177; at the time that exhibit was offered I stated that I had applied to the office of the Clerk of the Supreme Court of the United States for a copy of the original stipulation and after the paper I offered had been marked as an exhibit I received such copy, which I now offer in evidence in place of the other one. This is an authentication copy of the stipulation which is now offered in substituted for *for* the temporary one and I ask that it be marked Complainants' exhibit #177.

The Commissioner: Let it be marked.

(Marked Complainants' Exhibit #177.)

ASA HENRY PHILLIPS, a witness on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you reside?
A. Washington, D. C.
Q. What is your profession?
A. Civil and Mechanical Engineer.
Q. Will you state your age?
A. Forty-six this year; just past forty-six.
Q. Where did you receive your training and education for your profession?
3379 A. I graduated at Lehigh University in the School of Civil Engineering in 1890.
Q. And with a degree?
A. Degree of Civil Engineer.
Q. After that, what was your training or education in your profession, or your experience in your profession?
A. Soon after I graduated, some few months after, I became connected with the Engineering Department of the District of Columbia, engaged on drainage work, and was Assistant Engineer on construction work until 1900 when I was appointed Engineer and placed in charge of the preparation of plans for, and the construction of, a sewage disposal system for the District of Columbia; I was engaged on that work until 1908, when I was appointed superintendent of the sewer department of the District of Columbia, having charge of the construction, operation and maintenance of a sewerage system and sewage disposal system.
Q. In connection with occupation and experience which you have detailed did you do any outside work in the line of preparation for your career?
A. Yes. Directly in connection with our work at Washington I made a number of visits to, and studies of drainage work in Eastern Cities and along the seashore in connection with a detailed study of plans for the disposal system.
Q. What cities did you visit in that connection?
A. I visited Boston, New York, Philadelphia, Baltimore and also some of the Lake cities, Buffalo, Cleveland, Chicago.
Q. Did you visit Providence?
A. Yes, Providence, Rhode Island.
Q. In your visits what special work did you do?
A. It was an inspection of the drainage system, particularly as to the condition of discharge outlets and outfalls with a view of ascertaining as far as could be the condition of the streams and
3380 harbors into which the sewage was discharged, its general effect upon them and what might be done to better conditions as they existed elsewhere in our new work for Washington.
Q. Are you a member of any professional society?
A. I am a member of the American Society of Civil Engineers and the American Public Health Commission and several other more

or less local societies in Washington not connected directly with sanitary engineering.

Q. What is the population of the city of Washington?

A. The present population is about 350,000.

Q. And the area of the municipality?

A. The municipal area is about 70 square miles; 69.25 square miles, I think, to be exact.

Q. How long did you say you had been connected with the sewerage system of Washington?

A. I have been connected with the sewerage system of Washington for more than twenty-one years.

Q. What is the length of that system at the present time?

A. About 618 miles.

Q. Is it a separate or combined system of sewage?

A. It is a very generally combined system, with considerable mileage of separate system also.

Q. When you speak of "combined system" what do you mean by that exactly?

A. Drainage that provides for sanitary flow, house drainage, and for surface water, running water and sewage.

Q. How long has the present system been in actual operation in the city of Washington?

A. Five years.

Q. Prior to the time of five years ago, how was the sewage of Washington discharged with reference to the points of discharge?

3381 A. It was all discharged at the shore lines, wharf lines.

Q. Into what body of water?

A. Into the Potomac—into all the water front which is divided rather artificially by reclamation of the Potomac flats and into the Potomac River direct, the eastern branch of the Potomac and the Washington channel.

Q. Is there any discharge into the Anacostia River?

A. Yes; the eastern branch of the Potomac River is synonomous with the Anacostia River, it is just a different name.

Q. Will you describe the present disposal system of the city of Washington?

A. The present disposal system, by extensions and intercepting sewers along all the water fronts, collects the flow from the sewerage system itself and delivers it to the main sewerage pumping station, located within the city on the water front; there the sewage is passed first through sedimentation basins and then through screens, then through the sewage pumps, then through a skimming tank, from which it flows through submerged syphons, two six inch diameter pipes under the river to the opposite shore; then from there it is carried by gravity to the point of discharge down the Potomac River just above Alexandria; at the shore line it passes again into submerged pipes extending out to mid channel in the Potomac River in about thirty feet of water, with upturned elbows, and there the discharge takes place.

Q. How long is the outfall line, from the sedimentation basins, to the point of discharge?

A. It is between three and four miles, I do not recall the precise distance.

Q. How long is the sewage detained in the sedimentation basins, the skimming basins?

A. I would have to think of those figures for just a moment. I should suppose the average would be between five and ten
3382 minutes, very close to that.

Q. Won't you tell us what the character of the water is at the point of discharge of the Washington sewers, with reference to its being tide or land water?

A. It is tide water.

Q. Can you state the mean rise and fall of the tide at the point of discharge?

A. About 2.92 feet; it is called, commonly, three feet, but that is the average tidal range.

Q. How far up the river above the point of discharge does the tide rise and fall?

A. About seven miles; between six and seven miles.

Q. Does that take it up above the city of Washington?

A. Oh, yes.

Q. What is the minimum dry season flow of the Potomac River?

A. The minimum flow has fallen below a thousand second feet, not very much below a thousand second feet.

Q. Can you translate that for us into gallons?

A. Yes, that would be about 650,000,000 gallons per day.

Q. Approximately, what is the distance of the point of discharge of the sewage from the ocean?

A. It is about 100 miles from Chesapeake Bay and the mouth of the bay—of the river—is about 100 miles from the ocean; about two hundred miles.

Q. What is the discharge from your sewers into the Potomac River?

A. In quantity?

Q. In quantity.

A. From sixty to seventy-five million gallons per day.

Q. How long has this system been operated?

A. Five years.

Q. Has that been a continuous or intermittent operation?
3383 A. There has been no stoppage; it has been continuous from the day it started.

Q. Where is the point of discharge located with reference to the city of Alexandria?

A. The discharge above the old city is perhaps a mile and a half, but the city is building northward until it is getting much nearer than that to the outfall.

Q. How wide is the river at the point of discharge?

A. The distance from shore to shore at high water mark is between three and four thousand feet; the channel width is about half of that, less than half of that; it is about fifteen hundred feet.

Q. Have you made any examination of the river shores since the operation of the system as it now is?

A. Yes, I make regular examinations of the banks of the river along the stretch both above and below the point of discharge and outfall, and opposite.

Q. And have you made any examinations of the Potomac River?

A. Yes, I have taken samples of the bottom of the river above and below the outfall, in that stretch of water.

Q. Has that been done intermittently or periodically or systematically, or how have you done it?

A. That is done at regular intervals.

Q. What have you found to be the condition of the river shores in the vicinity of the outfall since the operation of the present system?

A. We have never found the slightest indication of any result from the discharge of sewage at outfall, on the shores themselves, that is, no material can be ascribed to discharge from the outfall; the shores are clean and entirely free from any evidence whatever of the sewage discharged.

3384 Q. Have you made any comparison of the conditions now with what they were before the system was installed?

A. Yes. The conditions along the river, cityward, are very much better than they were. I was on river work for ten years at Washington and I have found since the sewage disposal system has been in operation, the river shores all along the vicinity of the city, along the Potomac River, the Washington channel and the Anacostia River, are materially improved and are really clean, where formerly they were rather objectionable in a good many places.

Q. What were the results, as found by you, of the examinations of the bottom of the river in the vicinity of the outfall?

A. Our last samples, taken after we had had five years of discharge, were like all the others we have taken. We have rather a sandy bottom and the samples show absolutely no sludge deposit whatever.

Q. With reference to the water of the river at the point of discharge does it vary from time to time in clearness, I mean the natural water?

A. That is the river water?

Q. Yes.

A. The river, of course, at times is rather turbid and at other times it is very clear; with high storm discharges the turbidity of course increases very much.

Q. Have you made observations or have you not of the water in the vicinity of the outfall of the different conditions as to turbidity and clarity?

A. I have.

Q. What has been your observation as to the appearance of the water at the point of outfall, of the different conditions of turbidity and clarity as you observed them, so far as the influence of the discharge of sewage is concerned?

3385 A. The water has been so unaffected by the discharge that in the great majority of times it has been very difficult indeed to locate the discharge at all even in a boat I mean, passing over

it and searching for particular points; with our upward elbow discharge of course it makes a slight—the weight of the water discharging would have a tendency to make a slight rounding of the surface but even with that, we find it very difficult to locate it in the majority of times. It is free from floating material, from visable suspended material; it is not affected in color and there is absolutely no odor so far as I have ever been able to determine, even from a boat directly over the point of discharge.

Q. Are there any sleek or grease fields or sewage fields over the points of discharge?

A. I have never observed any.

Q. Or any evidences of surface grease observable by you?

A. No.

Q. You have not seen any?

A. I have not seen any.

Q. Have there been any tests made under your direction or observation as to the dissolved oxygen contents of the water of the Potomac River?

A. Yes, we make regular tests, three times a week, of samples of water at the outfall, and, for comparison, of samples of water in the upper river; these samples are taken at the same time, or, as nearly as possible at the same time, the boat proceeding from one point to the other, in order to keep a check on the loss in oxygen due to the discharge of sewage in the river at the point of outfall.

Q. The basin at the outfall during the past year, can you state what the oxygen contents show?

3386 A. They show a drop in oxygen, a maximum drop of about 12%—all our figures are on per cents—a minimum drop to zero and I think the average drop is about 4%. That is the difference between the oxygen determination in the upper river and the oxygen determination at the outfall. I would like to ask if I may have that question repeated.

Q. (Last question read.)

A. Perhaps I have not answered that. The minimum oxygen is a little under 60. The maximum 100, and the average about 85%.

Q. In the upper river, what did the determination of oxygen contents of the water show during the same period?

A. In the upper river samples for the past year we have a maximum of 100% saturation, a mean of about 92% and a minimum, I think, just under 70.

Q. Are there any fish in the Potomac River?

A. Yes, we have Potomac shad, herring, and in the lower river we have yellow and white fish, rock fish, cat fish.

Q. Where are these fishes caught?

A. At the present no seineing is done within the district on account of local laws to protect the fish, but from the district line down the river, for a very long distance, there is seining for herring and shad during the Spring and trap net fishing for other fish during the Fall, and, within the district, in the portion of the river near the outfall, we have considerable fishing for white and yellow perch, principally that, and the other fish I have named and some of the

best fishing grounds we have for fish of that character are along that stretch of the river.

Q. Is this fishing conducted at distances from the outfall or near the outfall?

A. One of the favorite places is perhaps a half a mile above the outfall at the Steel Company's wharf; another favorite place is at the mouth of Four-Mile-Run, right opposite the outfall. I
3387 say opposite, I mean on the Virginia side of the River as opposed to the District side.

Q. Have you any explanation to offer of the favorable conditions which have been testified to by you from the outfall or discharge of the sewage at the point in the Potomac at which it is now made?

A. After having had about nearly fifteen years' experience with the old system, and a study of the old sewers along the water fronts, and contrasting that with our five years' experience with our present discharge, it is my judgment that the excellent results we have obtained have been accomplished by the method of intercepting the sewage, primarily, that is by sedimentation, screening and skimming and incidentally the discharge through the pumps which tends to break up the solids and assists in the general work, but principly the removal of these wastes, largely organic wastes, which caused us a great deal of trouble along the water front at the mouth of our sewers, formerly.

Q. Have you had any opportunity for special determination of evidence in support of this conclusion, in your system there?

A. We had a particularly good case of that sort in connection with the construction of the sewage disposal system. It was necessary, of course, to complete one large line after another and after the Tiber Creek and New Jersey Avenue high level interception was completed it was necessary to connect the flow from the same with the temporary pumping station and to discharge the sewage into the river at the bulkhead line for two or three years before the whole project was completed and the large station ready for operation. This discharge was in a portion of the river where there were no other sewers and the sewage was discharged without sedimentation or treatment of any kind. We found, after we had been in operation less than a year, that we had a great deal of difficulty
3388 in the condition of the river front and, what was more objectionable and more troublesome to us, sludge deposits and during the succeeding summer and the summers thereafter, particularly it was quite offensive. There was a continual bubbling, bringing the considerable messes of sludge from the bottom up, with odors, and of course there was a bad surface condition from the visable presence of the sewage on the surface. After we put the whole plant into operation of course this disappeared in a comparatively short time.

Q. From your observation in connection with the Washington system what is indicated, in your opinion, as to the difference in the effect of the discharge of crude sewage without sedimentation, screening or skimming, and that of sewerage subjected to these methods?

A. I think there is every possible difference, the freedom from

surface indications of the sewage, the clearness of the water unaffected in color or odor, the absence of visible floating material and, at *our* outfall the entire absence of sludge, contrasted with the old conditions and with the conditions of sewers directly discharging elsewhere, all of which indicate about the same effect in the immediate vicinity of the discharge, lead me to conclude that the benefit of the treatment of the sewage is not valued nearly as high as it ought to be.

Q. On the city water front of Washington has there been any change since the introduction of the present system in the condition of the pier heads, wharves and boat houses from that which existed before it was introduced?

A. I think, as I stated, the conditions are very materially improved. There is an absence along the piles of the wharves and along the sea walls of the ugly effect resulting from nearby sewer discharge, it is practically absent. By that I mean it has
3389 now almost entirely disappeared. Of course, immediately after our system went into service these results hung on for a long time, but they are in admirable condition to-day in that respect.

Q. Have you made any observations to determine whether or not these objectionable conditions have returned below the point of discharge from the present sewage system?

A. Absolutely not; that is, we have had no such results. We have, immediately opposite the discharge, a small wharf, the U. S. Naval Magazine has a wharf immediately below the discharge and, as I have stated, in the examination and study of the conditions in that stretch of the river, we have found absolutely no indications of conditions such as are apparent at the city water front under the old system and no indication whatever of any effect from the discharge of sewage at the outfall.

Q. I show you a paper marked "Complainants' Exhibit 135" and ask you whether you have seen and examined that exhibit?

A. I have.

Q. Are you familiar with New York Bay?

A. I have been on it and around it for more than twenty years, rather frequently.

Q. Have you made a visit to it recently?

A. Yes, I have been around on a number of water fronts down the Bay.

Q. How lately?

A. Within the past ten days.

Q. And for the purpose of testifying in this case?

A. Yes.

Q. Where did you go on this last visit to the Bay, what parts of the bay did you visit?

A. I went across the upper Bay, along the shore of Newark Bay and down as far as Staten Island, then along the East River on the New York side and then on the Brooklyn side along the
3390 East River.

Q. Did you observe the conditions of the water on that visit?

A. Yes, sir.

Q. What did you observe along the shores of the East River as to the condition of the water so far as sewage is concerned?

A. I observed large quantities of sewage and very visable evidences; large sewage fields and quantities of sewage along the slips and at the pier heads.

Q. How far out into the river did these appearances show?

A. Along the East River the day we observed them I should think they would extend half way across, or possibly less, not more than one-third; I would say about one third the way across the river.

Q. Beyond that point what was the condition of the water as you observed it?

A. So far as it could be seen the water appeared to be generally in very good condition.

Q. Do you know where the proposed point of outfall of the Passaic Valley Sewerage System is located?

A. Yes I do.

Q. Taking Complainants' Exhibit #135 and directing your attention to the first paragraph marked "First", how does that system of purification or partial purification of sewage compare with that which you have in operation in Washington?

A. In all respects, that is in the three respects, it is very much more exacting.

Q. Take in the first place the element of screening, in what way is it more exacting than the screening which is applied to the Washington screening?

A. We have only the coarse screens and this provides for very fine screens. I might say that we are going into the fine
3391 screening ourselves somewhat, but not as this is. This is very much finer than anything we have. I do not think there is any definition here of what the coarse screens should be but judging from parallel practice elsewhere and in Washington I should imagine ours would be about the same as what is specified as coarse screens.

Q. In addition to coarse screens you observe that there is also additional screening?

A. Yes, sir. I say in the matter of screening it is a very much more exacting requirement.

Q. Now take the element of sedimentation and state in what respect this stipulation is more exacting as to sedimentation than is applied to, and is the case in, your work at Washington?

A. This sedimentation is far more exacting. It provides for about twelve times as much—more than twelve times, between twelve and eighteen times as stiff a requirement for sedimentation as we have.

Q. Now the third element you refer to, what is that?

A. That is the removal of surface oil and grease. That is not set forth in the stipulation, that is, there is no quantitative method of determining that this is more exacting but from the size of the chambers from which this would be removed, the surface areas available for the removal, they ought to have easily the opportunity to, and

should, remove that much more effectively. Of course, after you get to 100% removal you cannot get any more out of it, but the opportunity for removal would be there just the same.

Q. With reference to the condition of the waters into which the effluent is to be discharged by the Passaic Valley Sewer, simply with reference to the quantity for dilution, how do the conditions in New York Harbor compare with those in the Potomac?

3392 A. As nearly as I have been able to determine from the published figures in the various reports of tidal flow in the New York Harbor their conditions are about such as our maximum condition of river flow, based on the amount of dilution, per capita, for our river flow drops down until we have as small as ten to one dilution, or even under that of actual quantity at times.

Q. Your statement with regard to per capita flow in New York Bay, is that extended to the population tributary to New York Bay or not?

A. The whole population; as I remember the figures they run up on the estimated populations just as we do to a period running up to I think 1940; that the effective dilution is upwards of 250 to one or more.

Q. The stipulation which you have before you, contained in exhibit 135, provides for a point of the discharge of the effluent and the depth at which it is to be discharged; how does that compare with your Washington discharge?

A. We discharge in a little under thirty feet of water, this is stipulated to be forty feet of water. Both are channel discharges. The Washington sewage is discharged through two vertical elbows sixteen inches in diameter, discharged upward with no attempt made for a large field of spread for dispersion. This stipulation required multiple outlets on several lines, four I believe, covering a very considerable area. That, of course, must have a very great deal of influence in the rapid dispersion of the sewage and prevents the formation—probably one of the most objectionable features of concentrated discharge—of masses of sewage.

Q. Which in your judgment is likely to be the more efficient?

A. Absolutely the multiple discharge.

3393 Q. As to the element of depth of discharge, is there or is there not any advantage in having it ten feet deeper than the Washington discharge?

A. That would assist materially in the dispersion; the greater the depth the more satisfactory is the dispersion.

Q. With the effluent produced by the process described and specified in complainant's exhibit #135 which you have had before you, and discharged as therein specified, in your opinion, based upon your experience at Washington and elsewhere, will there or will there not be an absence in New York Bay of visible suspended particles coming from the Passaic Valley Sewage?

A. In my judgment there will be an absence of visible suspended matter.

Q. Will there or will there not in your opinion be an absence in New York Bay and its vicinity of odors due to putrefaction of or-

ganic matters contained in the Passaic Valley sewage thus discharged?

A. In my judgment there will be an absence of odors.

Q. In your judgment will there or will there not be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley Sewage at the dispersion area or elsewhere?

A. In my judgment there will be an absence of grease and a substantial absence of color.

Q. In your judgment will there or will there not be a public or private nuisance created in New York Harbor by this discharge?

A. In my judgment there will be no public or private nuisance created by this discharge.

Q. In your judgment, based upon your observation as to fishing in the Potomac below your outfall, will there be a reduction
3394 in the dissolved oxygen contents of the waters of New York Bay resulting from the discharge of Passaic Valley sewage to such an extent as to interfere with major fish life?

A. In my judgment there will not be such a reduction in dissolved oxygen as to interfere with major fish life.

Q. Have you any knowledge of any sewage system discharging into any tidal water under as stringent conditions as to purification as are proposed for this discharge?

A. I presume the question refers to the discharge of large cities?

Q. Yes.

A. Not to any special or small——

Q. Yes, I am referring to city discharges.

A. I know of none.

Q. Are you familiar with the Boston system at all?

A. I am.

Q. How does that compare in stringency to the condition of the effluent with the conditions imposed in this stipulation?

A. The conditions are much less than ours at Washington and very much less stringent than those required under the stipulation.

Cross-examination by Dr. O'Sullivan:

Q. What is the character of the sewage at Washington as to whether it is residential or whether it is admixed with trade wastes?

A. The sewage of Washington is very largely residential.

Q. What trade wastes, if any, are added to the sewage?

A. As the term is ordinarily understood we have comparatively little. We have a few—one or two—pulp mills from which we get some discharge but our principal source of material of that
3395 sort is from the government operations, principally from the Bureau of Engraving and Printing; from that we get large quantities of plate printer's ink and with it a very great deal of color as well as heavy material.

Q. What are the constituents of trade printer's ink?

A. I cannot answer that.

Q. What are the organic matters in addition to trade printer's ink?

A. You mean in the sewage or in that particular discharge?

Q. We are discussing the trade wastes from the printing office, I understand.

A. No organic matters at all.

Q. So that the trade waste would largely consist of this ink you have described?

A. That is one class, as affecting color, as giving an objectionable sludge. Of course, we have quite a number of slaughter houses; the discharge there is not very large, but there are a number of them.

Q. Do you take care of the refuse from these slaughter houses in your sewage disposal system?

A. Oh, not all of it; we take care of such as is admitted to the sewer.

Q. What percentage is admitted to the sewage system?

A. That I could not answer. I know there is a very considerable amount of material that we endeavor to keep out of the sewers which gets into them; heavy material.

Q. Where is that discharged?

A. That passes through the sewerage system to the sewage disposal system.

Q. Do I understand you that you do take care of all the refuse of these slaughter houses?

A. No, sir.

Q. Then, I say, the part you do not take care of, where 3396 is that discharged?

A. That is removed by the people themselves. I cannot tell you exactly what treatment that undergoes. Of course, not all the discharge from any slaughter house enters the sewer. It would not be practical to carry it through the sewers in any sewage system anywhere, but a very large part of it does get in; the blood, some particles of the entrails and particles of putrifactive material, and that we get.

Q. What I am trying to get at is where is the refuse that you don't get, how is that discharged?

A. It is not discharged, it is probably removed, it may be burned; I don't know, the great mass of entrails and material of that sort that are solid and heavy could not be discharged into a sewage system or into a sewer; they have no local discharge, if I understand your meaning. What other sewers might they discharge in? There are none.

Q. What is the salinity of the water at the outfall in the Potomac?

A. About zero salt.

Q. Practically fresh water?

A. Yes, sir.

Q. Have you had any experience with work in bra-kish or salt water?

A. I spent a lot of time in Boston Harbor and their sewage outfalls are in salt water.

Q. What is the salinity of the water at the Deer Island outfall?

A. That is pretty close to ocean water.

Q. Do you know that of your own knowledge?

A. Exactly what it is? I do not.

Q. Do you know what the salinity of the water in New York Upper Bay is?

A. I do not from actual tests I have made myself, I know
3397 what it is from my reading of reports of the Sewerage Commission upon it; that is, I believe I do.

Q. What do you recall it to be?

A. I recall it as one-third fresh and two-thirds salt; that is my recollection of it. In the Upper Bay, I understood you to say?

Q. Yes.

A. One-third fresh and two-thirds salt is my recollection, in round proportion.

Q. Does it make any difference in your opinion as to whether sewage is discharged into fresh, bra-kish or salt water as to its ultimate digestion and assimilation?

A. It has been my opinion for a long time that salt water or bra-kish water, where it was a considerable part salt water has certain advantages over the fresh water; as a matter of fact it is a pro and con proposition, there is some advantage on one side and some on the other, but altogether I have rather been of the opinion for a long time that salt water was a more satisfactory dilutant than fresh water, though not in every respect.

Q. In what respect is it not?

A. Fresh water has a more high capacity for oxygen, fresh water has a lower specific gravity. That is about all the difference.

Q. What factors make for the disintegration of organic matters discharged into either fresh, bra-kish or salt waters?

A. I don't know whether I get your question exactly, disintegration?

Q. Disintegration.

A. Will you repeat the question?

Q. (Question read as follows: "What factors make for the disintegration of organic matters discharged into fresh, bra-kish or salt waters?")

3398 A. If, by disintegration you mean the breaking up of solid materials I would say current, wave action, winds, marine life and factors of that sort.

Q. What percentage of the Washington sewage is organic matter?

A. That I could not answer; it is so variable in itself and it is a pretty difficult question to answer in any quantitative way.

Q. Can you give me an approximation?

A. The best definition of it probably would be the quantity per capita, inasmuch as the organic matter is very closely a factor per capita rather than per gallon or per quantity of the sewage itself. Our quantity per capita is about between 150 and 200 gallons per day.

Q. That indicates a large amount of fresh water in that sewage, does it not?

A. Yes, we have a rather large proportion of water.

Q. What is the meter consumption of water per capita in the city of Washington?

A. The city is only in a comparatively small part metered; there are estimates made of the daily water consumption but they are not from actual meters.

Q. What is the estimated per capita consumption of water in Washington city?

A. I think the average is somewhere about 160 gallons.

Q. If the average water per capita consumption is estimated at 160 gallons and you who are in charge of the sewage disposal system estimate the sewage per capita at 160 gallons, that would leave very little organic matter in the sewage would it not?

A. Well that is getting it a little fine. You know the percentage of organic matter in sewage is not very large and is not such
3399 as to very appreciably increase the total volume in any city anywhere.

Q. What I am getting at is that the organic matter in the Washington sewage is a very slight proportion of the sewage?

A. Oh, no, I would not say that.

Q. And what do you estimate it at?

A. As I stated a while ago, when you asked for a definite measurement, it would be perhaps the per capita daily consumption, for instance, if our average daily consumption is 160 gallons per capita and in adjacent places it were 80 gallons per capita, that would measure very fairly the strength as we speak of it of the sewage; that is, our sewage would have one-half the strength of the sewage of the place where the water consumption was 80 gallons per capita.

Q. Using these terms, would you describe the sewage of Washington as weak sewage?

A. No, I would not.

Q. Would you describe it as strong sewage?

A. No, it occupies a fairly middle ground and about on the proportion of the per capita in consumption; the per capita consumption, that is, is not largely above the per capita consumption of a great many American cities, and even smaller than some, and comparing the sewage on the same basis with that of other cities, it is certainly not the strongest.

Q. How would you define strong sewage?

A. Very much as I have indicated; that is as good a basis of measurement of it as anything I know of, that is, the total amount of quantity as against per capita.

Q. So that in measuring sewage you take the per capita water consumption and estimate on that basis the sewage per capita output?

A. Yes.

Q. What is the rapidity of the Potomac current during ebb
3400 at the outfall of this system you have described?

A. It will vary very much with different discharges of the river, normally the ebb is from one to two or three miles per hour.

Q. And running up as high as what?

A. Why I suppose it would get up as high as four or five miles.

Q. Would that exercise any scouring action at the region of the outfall?

A. I suppose there would be some slight action; I would not

gather from the studies I made of the bottom there would be very much, because of the materials we have taken up from the bottom such as leaves, for example, that would not resist very much the scouring action and we frequently get those right at the outlet.

Q. What is the grade of your sewers at Washington toward the outfall?

A. Going to the outfall we have a grade of 1 foot in 3000.

Q. Do you get a pretty rapid discharge to the outfall?

A. We get a very fair discharge which will vary from perhaps two and a half to three feet per second, or slightly more than three, a shade more than three under the highest discharge.

Q. The sewage would be very fresh when it reached the outfall—would you describe it as fresh sewage?

A. Oh, yes, it is fresh sewage; our average sewage would be about four hours old, possibly a little more.

Q. And practically all domestic sewage?

A. Very largely domestic sewage, yes.

Q. Have you ever tested the sewage effluent to make oxygen determinations, before discharge in the Washington outfall?

A. We have had some tests of it but we have not main-
3401 tained any regular work on it.

Q. But you have found a fair percentage of oxygen in the effluent?

A. No, I think the only tests we have had have shown practically none.

Q. No oxygen?

A. Or very little, there has been some but it has been very slight.

Q. I understood you to say that you had done regular oxygen work in the neighborhood of the outfall?

A. Yes.

Q. And the oxygen averages 89%?

A. No, it averages 89% for the past year; my recollection is the question was as to the past year, but that varies very much from year to year.

Q. What would be a fair average for the five years?

A. I would put the average for the five years as about 80; possibly slightly over 80; about 80 I should say.

Q. What was that minimum of 60%; when did you get that?

A. That was during the past year.

Q. What did you attribute going below the average for the five years of 20% to?

A. What did I attribute that to? That is due to a lot of complex conditions; it is due to the temperature variation, it is due to the condition of the water of the river above, not affected from our sewage discharge. There are times in the year when it has a good deal more work to do on organic matter, other than the sewage, which reduces its oxygen, so that it comes to us lower in oxygen. Then there is the variable flow of the river and in getting down towards minimum flow we have less water and less oxygen for the work of reducing the sewage.

Q. How far up the river do your determinations extend for oxygen contents?

3402 A. Our upper sample on the river water is taken very near the highway bridge across the river, that is, opposite the Potomac Park.

Q. Well within the city limits is it?

A. Oh, yes.

Q. I asked how far up the river, above the city limits, you have made oxygen determinations?

A. We have made none, the sewer department.

Q. On what then do you base the statement that the river water comes to you lowered in oxygen at certain times?

A. From the results we get from the samples taken above the city, that is, above the effect of sewage discharge, where there is no sewage discharge; that is, above the Washington Channel a mile or more. The only portion of water front where there is sewage discharged is below this point where we take our samples and we consider that a sample of river water taken there is a fair way to determine the condition of the water above the point where it is affected by the discharge at outfall.

Q. If I understand you right you do not make any determination above the point of discharge of your sewage, is that correct?

A. Oh, yes, we do, this point I am speaking of is way above the point of discharge, several miles above it.

Q. And well within the city limits?

A. Oh, yes. Well, the city limits—we have no city limit really, the District of Columbia extends miles up the river. You see we have about seventy square miles of country and that covers nearly ten miles of water front.

Q. Are there any other sewers discharging, besides this trunk sewer outfall you are speaking of, into the Potomac River north of that trunk sewer outfall?

A. No, there are practically none, there are a few houses along the shore above the city, but there is very little discharge of sewage; it is a negligible quantity.

3403 Q. Then what organic matter do you say lowered the oxygen contents of the water before it reached your outfall and the neighborhood where you make your determinations?

A. If the river only had a draft on it from the sewage for reducing its oxygen, there would not be any; but all the processes of nature are using up oxygen and we have organic matter to be decomposed in very large quantities other than that of sewage; that work must be going on in all streams.

Q. What organic matter besides the sewage, that you know of, is being decomposed there in the river that lowers its oxygen contents on some occasions to 60% of the saturation point?

A. The 60% that you refer to is the percentage of oxygen in the dilution basins after the application of the sewage.

Q. And outside of that basin am I correct in saying that it never goes below 80%?

A. No, I think not; I think it has gone below 80%.

Q. Of your own knowledge do you know how much lower than 80% it has ever gone?

A. I have not the figures here; my recollection is, of the averages during the past year to which I have referred that it goes as low as 70%; that is, river water above the influence of the sewage discharge.

Q. Who makes the oxygen determinations for the sewage disposal system of Washington?

A. They are made by our chemist.

Q. Have those figures ever been published?

A. Oh, yes, they are published in my annual report every year, not all of the figures, but a summary of them and quite a number of figures, as much as we can give space for.

Q. Have you made any bacterial determinations for the water in the vicinity of the outfall or above the outfall?

A. We have not.

Q. What becomes of the organic matter discharged into
3404 water; how is it finally disposed of?

A. It is transformed by bacterial influences, it becomes into inorganic matter.

Q. With a high average like 80% in the neighborhood of the outfall did it occur to you that this bacterial or biological disintegrating process took place lower down the river than the territory covered by your commission?

A. From examinations made, oxygen determinations made, below the outfall, and on down the river for quite a considerable distance, we did not find that to be the case. In fact it was by a process of observation of that sort that we determined points for taking our samples, having, of course, reference to convenience and minimum distances of travel for that work.

Q. Is it not a fact with that head in the sewer it might be considered a rapid discharge of the sewage and being discharged into a river whose velocity you state is about three or four miles, does it not occur to you that the sewage is transported quite a distance below the city before these biological changes have an opportunity to begin?

A. In answer to that I would say, in regard to river velocities, the question I was asked was what was the maximum velocity at ebb tide. As a matter of fact, at the outfall we have substantially as much current, or as long a period of flow, on the flood as on the ebb and the sewage at outfall oscillates with the tide through a number of cycles before any particular part has finally passed below the point of actual outfall.

Q. Of actual discharge?

A. Of actual discharge.

Q. Have you conducted any float observations to determine that fact?

A. We have.

Q. How long does it take the Washington sewage after its discharge to go below the point of discharge on a flood tide?

3405 A. That would have to be qualified by a statement as to the time during flood tide when the discharge occurs, that

occur-ing near the end of a flood tide would have a very different history than that occurring at the beginning of the flood tide.

Q. Give both, you have taken float observations to determine that fact?

A. Perhaps the clearest answer I could give to that would be the range of tides, in number, that is the maximum and minimum number, that we have found covered that period of oscillation. I think our minimum number of tides is four, our maximum number about double that, about eight or nine tides.

Q. What do your average observations determine for you with regard to the length of time it takes this sewage to pass the point of discharge on a flood tide?

A. That is the average time?

Q. On a flood tide.

A. I do not think really I can answer that question as it is put. If you mean the average it would be one answer because not only do we have the tide, but we have the condition of the river flow as a factor in that. As I stated, the range of discharge under normal conditions, that is, within the range of normal conditions, is from four to eight tides to pass clear of the outfall.

Q. Do you know whether or not there are deposits from your sewage at Washington below the point of discharge, sewage sludge such as you have described——

Mr. Riker: I object to the question because he has not described any sewage sludge in the river; on the contrary, he said there was not any.

The Commissioner: Note the objection of defendants' counsel.

A. None of our examinations have shown any sludge de-
3406 posits whatever.

Q. At any point?

A. At any point. From an examination of the river below, I mean for very considerable distances below, covering a reach perhaps of thirty or forty miles of river, not however by examinations through taking samples of the river bottom, but from other evidences I would certainly conclude there were no solid deposits chargeable to Washington sewage after the screening of our sewage and after the sedimentation and after the pumping.

Q. Have you not described it as being very finely comminuted when it gets to the outfall?

A. Yes, sir.

Q. What evidence have you to support your contention that there was no indication along the shore of gross parts of sewage; there was no evidence of gross sewage pollution that you saw along the shore as I understand it?

A. The examination I referred to, of course, was not with the idea of finding any large masses of sewage, but we have a tidal range of about three feet with a considerable shore exposed at low tide and of course a considerable reach beyond that exposed at the ordinary high tide and we see the effect on the shore by the deposits of the receding tide of even very small particles of organic matter;

the first indication of that would be odors, it would have a very disagreeable effect on the sense of small, at low tide especially in hot weather, in the summer time. It is rather such indications as that we rely upon to determine whether we are doing any injury along the shore in that respect.

Q. Do you know as a matter of fact that several complaints have been lodged with the Governor of Virginia and the matter is now being agitated in the legislature of Virginia so as to secure measures to abate the nuisance caused by the sewage of Washington city?

3407 A. Not at all along the line we have been speaking of: The matter before the State of Virginia has nothing to do with that and absolutely has no foundation in the way of local complaint. If I might state what the situation is—the Pure Food Board of the Department of Agriculture has condemned some Potomac oysters and this has aroused a great deal of activity and indignation of the part, of course, of the owners of the oyster beds and there is now a biological survey being started by the Public Health authorities, the Marine Hospital service, that has been started on my recommendation and to which I made some reference in my last annual report, to determine whether, at a distance of from eighty to one hundred miles any effect that the Pure Food experts may find in the way of Typhoid fever germs, disease bearing germs, either within the oysters or within the waters in the vicinity of the oyster beds is due to the Washington discharge of sewage. That is a very much mooted question just at present and we are going to make a very thorough survey that will take a year or more, with samples taken frequently, to determine that. But that is a very remote thing.

Q. Have they not found very large deposits of sewage from Washington sewage that was suffocating these oysters?

A. Absolutely no, sir.

Q. Have they not made that complaint?

A. I never heard of such a complaint?

Q. What provision in your sewage disposal system is there for the removal of organic matter in solution?

A. Before discharge?

Q. Before discharge.

A. Of organic matter in solution? None.

Q. What provision have you made in your sewage disposal system for the removal of colloidal matter before discharge?

A. None.

3408 Q. What provision was made in your sewage disposal system for the removal of pathogenic germs before discharge?

A. Perhaps I might say none to that; but we really have done something, we have constructed on hospital discharges automatic disinfecting plants for the sewage; we have built two of those for hospitals coming under the control of the District Health Officer, the Health department of the District, with that exception, none.

Q. So that you don't really know whether their complaint would be well grounded on the idea that they were getting typhoid infec-

tions from your sewage, that is one of the easiest ways of getting it, from the oysters; that is the complaint, is it not?

A. No, the complaint is a little more complex than that. The people in the district eat the oysters but the people who are complaining are the owners of the oyster beds who have had their oyster beds condemned; not many of them, but some of them. I might say in regard to that a good deal more, the department of Agriculture itself across their map have put a line, a zone, where oysters are not safe to take, not due to any effect of sewage discharge or any disease bearing germs on those oyster beds as determined from observations but from samples of water and samples of oysters, purely of course, in the way of typhoid germs; and below that they make the oysters absolutely safe. The part they mark as being dangerous, and that is the way they mark it on their chart, is the very upper edge of the oyster beds; so far as the district is concerned, those beds are from eighty to a hundred miles below the river with the nearest bed, that is the upper fringe, with a very few oysters, sixty miles below, apparent to anyone entirely too far away to be effected by any deposits from the sewer. But they do not condemn
3409 the oysters from the river, they simply mark out those spots as dangerous, but they do not condemn the oysters from that area; they take samples of the water and if they find a cargo of oysters at the wharf they take some samples to the laboratory and if they find a germ they condemn the cargo. Oysters are coming to us all the time from the Potomac and are passed by the Pure Food Board.

Q. Is Dr. Sloan not one of those in charge of that?

A. Yes, sir.

Q. Have you any doubt that on an ebb tide your sewage effluent will go over those oyster beds?

A. Absolutely none.

Q. You have none?

A. No, there is no sewage by the time it reaches the oyster beds, it has gone in the wash; it has, as I say, about eighty miles to travel.

Q. Are you familiar with the biological processes by which it is disintegrated?

A. Not as a biologist.

Q. Are you a bacteriologist?

A. No, sir.

Q. Have you any idea of the length of time it takes under favorable conditions, with an ample supply of oxygen, to distintegrate organic matter?

A. That would depend so much upon so many circumstances that I don't think it is possible to give an answer. I am giving favorable conditions, fresh water conditions.

A. Ample oxygen?—And of course the material being acted upon must be in such a condition as to give the most favorable opportunity for action. For instance, masses of organic matter must be broken up at first by slow processes before such action can take place. It is a very difficult thing.

Q. What familiarity have you with the Upper Bay outside of what you have testified to?

3410 A. You mean here in New York?

Q. New York Upper Bay?

A. I have practically only such as I have testified to.

Q. What is the depth of the sludge deposits in New York Upper Bay?

A. I could not state that; I have read figures on the subject, of some examinations that have been made.

Q. What is the condition of the oxygen contents of the East River between 42nd Street and the Battery?

A. That I could not state; I have read the results of investigations but I cannot recall them.

Q. How low would you think it would go?

A. Average or maximum or minimum?

Q. Minimum.

A. I suppose it would go down below 50 for the minimum.

Q. Do you think fish could live in a river with the oxygen contents at fifty?

A. If they do not stay there all the time, sure.

Q. If they stay a little while they might live in it?

A. Oh, yes, easily enough at fifty; I doubt very much if it would affect the fish because it is not uniform and it is not constant. A great many figures have been given, perhaps they are all guesses, as to how low that oxygen per cent falls before it is a determined fact that fish will not live.

Q. Have you had any experience with fish and oxygen outside of Washington where you say fish can live in oxygen contents of 89% and are caught there?

A. Oh, yes 60%.

Q. You have caught them when the oxygen contents in the Potomac have been 60?

A. Yes, sir, they are fishing there right along with the oxygen contents at 60.

Q. And it is quite frequently as low as that?

3411 A. We have it at times.

Q. And that would be in the neighborhood of the outfall, would it?

A. Yes, sir, right there close to the outfall.

Q. How low an oxygen percentage can fish live on?

A. That would depend on conditions, whether it was continuous, whether it was variable in different portions of the volume of water in which the fish are living, whether it remained constant at that percent or varied. It always appeals to me to be a very clear comparison with ourselves, that we can live in a room with mighty bad air for a time if we can get out in the fresh air, and a good many of us have to at times; and we live for days in out-of-door air in the country air; then we have the city air and we have the close air of rooms and then too we have the bad air of closely crowded rooms. The same kind of experience it seems to me could be applied to fish life as to human life.

Q. Can fish live in water where the oxygen never rises above 50% of its saturation limit?

A. That I don't know.

Q. What is the percentage of the oxygen contained in the Passaic River at ebb and flood?

A. I don't know that, it must be very small.

Q. Would you call 37% small?

A. As an average?

Q. Yes.

A. Yes, sir, small.

Q. What occasions below the oxygen contents of Passaic River as against the Potomac River?

A. They put too much of a burden upon it, it is carrying more than it can carry.

Q. Do you know what the tidal conditions are in the Passaic River?

3412 A. Do you mean what is the range of tide?

Q. Yes.

A. I don't know it in feet, no.

Q. Do you know what the depth of the river is?

A. No, I have seen it at different sections but I could not recall in feet what the depth is.

Q. Do you know what manufactories discharge trade waste into the Passaic River?

A. I could not answer that; I have seen some statements of it, but I don't know, I am not familiar enough with the local conditions to give a statement of it.

Q. There are a large number, would you say?

A. I would say there are a great many.

Q. And they discharge considerable organic trade waste?

A. I should say so, yes.

Q. And considerable spent liquors?

A. Yes, sir.

Q. Are you familiar with the effect of spent liquors upon waters in which they are discharged?

A. That is not a type of discharge that I have had any direct experience with.

Q. Do you know of the condition of Monongahela River, the discharge of acid wastes?

A. Yes, sir.

Q. Do they not destroy the bacterial forms of life that you say disintegrate organic matter?

A. They are supposed to be injurious to them.

Q. Do they absolutely destroy them?

A. Yes, sir.

Q. Have we many of those acid wastes in the Passaic River?

A. I do not know.

Q. Do you think it is a fair comparison; considering the

3413 large amount of trade waste and domestic sewage contemplated to be carried by the Passaic Valley Sewage, do you

think it is a fair comparison with the Washington city, which is practically entirely residential?

A. Of course there is that difference; at the same time there is a much better natural vehicle for dilution here than in Washington.

Q. Why?

A. It is much larger and more effective, at the point of discharge proposed by the Commission, in my judgment. As to the matter of trade wastes, I do not think that is really, from an engineering point of view, nearly as serious as it is made out because it is up to the people who have to deal with the sewage to require those having such trade wastes to take care of them, to specially provide for them, so as not to make them an unreasonable burden on the sewerage system.

Q. What provision is made in Complainants' Exhibit No. 135 that would eliminate thereby trade wastes from the effluent?

A. There is none so far as I can recall.

Q. What provision is there for the elimination of organic matter in solution from the effluent?

A. Before discharge?

Q. Yes.

A. There is none so far as I know of.

Q. What provision is there made in the stipulation, Complainants' Exhibit No. 135 for the elimination of pathogenic germs from the effluent before its discharge?

A. None, so far as I know of.

Q. I think you said that in your plant down there in Washington you made about five to ten minutes' sedimentation?

A. Yes, sir.

Q. That is rather short, is it not?

3414 A. Yes, sir, and still we get a very large amount of sedimentation in that time.

Redirect examination by Mr. Riker:

Q. Are pathogenic germs more likely to be carried by domestic sewage or trade wastes?

A. By domestic sewage.

Q. Provision for the removal of organic matter you say is not contained in this stipulation, Complainant's Exhibit 135?

A. I do not think the question was as to organic matter, if it were my answer was incorrect.

Q. Organic matter in solution?

A. Yes. I take it that means exactly what it says and I do not find that there is any provision for the removal of that.

Q. Will you explain just what you understand by organic matter in solution?

A. It would mean the organic matter that remains after careful sedimentation, screening and skimming in such fine particles as not to be removable by those means, and in such condition as to be readily and efficiently acted upon by the dilution.

Q. Do you find in the stipulation which is Complainant's Exhibit 135 a provision for the removal of organic matters?

A. The processes as set forth in that stipulation certainly provide for the removal of organic matter.

Q. You say you find, as I remember your testimony on cross examination, that in the stipulation in question there is no specific provision for the removal of acids and other trade wastes, as such, am I right about that?

A. That was my statement.

Q. In the guaranteed results, if they are produced, in your opinion is it necessary to remove these trade wastes and
3415 deposits in order to produce the results guaranteed?

A. It would be necessary to remove them or to so reduce them as to effect the results covered by the guarantee.

Q. Could or could not that removal be accomplished either at the disposal plant itself or at the point of production of the trade wastes?

A. It is very possible that it could be accomplished at either point, with probably a more effective result at the point of reduction.

Recross-examination by Dr. O'Sullivan:

Q. Do you make any distinction between septic sewage and fresh sewage, in their disposals?

A. Oh, yes.

Q. Are you in favor of a trunk sewer, a long trunk sewer, say twenty-six miles long, rather than local disposal at the point where the sewage is created, as it were?

A. I certainly am, and I might state in that connection something about our work at Washington. We have a very large population that is growing in two comparatively small stream valleys outside of the district whose only discharge is into those small streams that flow through a park in the District of Columbia. We have gone to a very great expense to prevent the disposal of any sewage into any of these streams, in a very large area and we are now formulating a plan by which we propose to take into our sewage system the sewage of the towns and communities lying in that territory, outside of the District, in the State of Maryland; that would require a construction, beyond our lines, of about ten miles in each valley, roughly. Meanwhile, our sewage is flowing through our sewers; some of it has to come about twenty miles before it gets to our plant and that would add some three miles that we have yet to build to reach the District which runs ten miles be-
3416 yond, thus adding thirteen miles in length to our system. We have come to the conclusion that we can safely take care of that and discharge that sewage, as fresh sewage, into the Potomac, from our experience in handling the sewage that travels through our own system, quite a distance, as I say, up towards twenty miles.

Q. Would this sewage be of the same character as the sewage we are now dealing with, namely, residential or house sewage?

A. That is very difficult to predict; I should say that it would be very largely, at the same time there is a tendency owing to lower taxes and freedom of restraining influences existing in the Capitol to the development of manufacturing concerns outside, along the

borders of the District, to put such development in this territory so that we would probably begin to get a different class of sewage from our own.

Q. How old would that sewage average when it got to the outfall?

A. I suppose our average sewage would be just about what they have here in the Passaic Valley, I should — eight or nine hours.

Q. What is the grade contemplated for the Passaic Valley Sewer?

A. That I cannot tell you offhand, I have seen it but I cannot remember.

Q. Can you tell the age of the sewage that travels a long distance without knowing the grade of the sewer?

A. No, but I can be at it all day and remember what I get as a result; I remember the result but not the details. I figured it out as taking eight or nine hours, taking quite a number of different figures, the length, the grade, and so on, and I cannot recall
3417 the origin of the result I reached now, all the proportions along the line, but they are given I think in one of the Passaic Valley reports, if I remember correctly.

Q. How many of the Passaic Valley reports have you seen?

A. Indeed I don't know, I have seen several of them.

Q. You have?

A. Yes, sir.

Q. More than two or three?

A. Oh, no, I think now. Well I don't know as you call them all reports, I have seen one, and perhaps the earliest and some partial reports, one I remember was in pamphlet form and I think that was the latest one, if I remember correctly.

Q. Which was the first one?

A. It seems to me the earliest one is rather a large volume, rather a long one; I cannot recall the year now, I did not make any special note of it.

Q. Have you seen the plans and specifications for the trunk sewer project?

A. I have.

Q. And the *the* sewage disposal system?

A. That is their pumping plant and sedimentation plant?

Q. Yes.

A. Yes, sir, I have.

Q. And you have studied those various plans?

A. Yes, sir.

Q. Can you state any facts in relation to the sewage disposal system that differ from your Washington plant?

A. In detail it is quite different from the Washington plant. In the Washington plant, taking sedimentation first, we have a single sedimentation chamber somewhat larger than the grit chambers as indicated on the drawings for the Passaic Valley plans, and that is all the sedimentation we have, whereas, with the plant here the plans show grit chambers through which the flow goes after
3418 passing the coarse screens, then it goes through the pumps, then through the sedimentation basin where there is a very

considerable period of time allowed, an hour I believe as a minimum and an hour and a half as an average as I recall it, for the deposit of material held in suspension. Then as to the screens, we have double sets of coarse screens, what are generally known as coarse screens, that is, gates with bars that really present a series of slots through which the sewage must pass, whereas in the Passaic Valley plant they provide for very fine screens.

Q. How long is the trunk sewer?

A. The Passaic Valley trunk sewer?

Q. The Passaic Valley trunk sewer.

A. Do you mean from the point of outfall to the upper limits?

Q. From the head of the sewage system.

A. I think it is about twenty-five miles.

Q. And you have no idea of the grade?

A. I cannot recall the grade, I have seen it.

Q. Would you say whether it is a slight or whether it is a heavy grade?

A. A grade is such a variable thing; to an electric railroad man a grade is one thing and to a steam railroad man it is another; it depends on what you call a heavy grade.

Q. We are speaking of a sewerage system.

A. We think our outfall sewer has a good grade at a rate of one in thirty-six.

Q. And would the Passaic Valley have a lower or higher grade than that?

A. I think it is heavier.

Q. You think it is?

A. That is my recollection.

Q. You are familiar with the land along the Passaic 3419 water shed?

A. Yes, I have been along the river.

Q. What extent of territory is it comtemplated to serve by the Passaic Valley plant?

A. In area?

Q. Yes.

A. I think about one hundred miles approximately.

Q. And what population?

A. The current figures as I recall them are about seven hundred thousand.

Q. Do you know whether it is more than that?

A. I do not, I do not recall exactly; it is in the neighborhood of seven hundred thousand as I recall it. I am speaking now of the present population in the Valley.

Q. I understand you studied these plans to determine their efficiency to accomplish the stipulation set forth?

A. Yes, sir.

Q. What population will that trunk sewer scheme serve in 1940?

A. That is, what is the estimated population in 1940 in the Passaic Valley?

Q. You say you have read their reports?

A. Yes, sir.

Q. And you have studied this project.

A. Yes. Well you see it is a pretty difficult thing to make answer to some of the questions because I think the report as early as 1903 gives a population of, I think, as low as five hundred thousand. I have seen some later figures and I cannot recall whether they are the 1912 figures or not, and I remember they are in the neighborhood of seven hundred thousand.

Q. Do you remember whether some populations were
3420 shrunk with the view of affecting the contractural relations with the Passaic Valley Sewerage Commissioners?

Mr. Riker: Objected to as not cross examination on anything this witness has testified to and as immaterial and irrelevant in any view of the case.

The Commissioner: Note the objection of counsel for the defendant.

A. I do not.

Q. Do you know whether those populations that would read in 1903 as estimates were grossly below the actual populations in 1910, although they were estimated for 1940?

A. All the populations to which I have referred were not estimated for 1940; they were the existing populations at that time.

Q. What was the first estimate for the year 1940 that you have read from the matters that have been submitted to you in relation to the Passaic Valley Trunk sewer project?

A. The estimate of the earliest date I cannot tell, I do not recall because I did not make any notes from it.

Q. Were the plans and specifications presented to you designed to merely serve the present population?

A. Oh, no.

Q. What distance in the future did they extend to?

A. I believe to 1940.

Q. And to serve what population?

A. I cannot recall. My recollection as to quantity I can recall a little more definitely perhaps, although I am not clear at all on either one.

Q. What number of distinct and separate communities does this Trunk sewer project of the Passaic Valley Sewerage Commissioners design to serve?

3421 Mr. Riker: I object to the question on the ground that "communities" is not a definite word which this witness can understand and apply and answer to.

The Commissioner: Note the objection of defendant's counsel.

A. I cannot state.

Q. Do you know the character of the trade wastes from the different communities and what effect they would have on domestic sewage coming from these communities?

A. No, I do not think I can answer that question.

Q. What other trunk sewer project have you ever had submitted

to you beside this prospective one of the Passaic Valley Sewerage Commissioners?

A. This is the only one.

Further redirect examination by Mr. Riker:

Q. Have you made any examination of the Boston system?

A. I certainly have.

Q. Is that a trunk sewer system?

A. Yes, sir.

Q. Have you had any experience with the Washington system?

A. I certainly have.

Q. Is it a trunk sewer system?

A. It certainly is.

Q. Are there any others that you have examined?

A. Oh, yes, I examined systems in a number of cities, as I have testified to.

Q. Then exactly what did you intend when you said that you had had no plans submitted to you for other systems?

A. I understood the question to be whether I had been called upon in advance of construction to express an opinion as to the feasibility of a sewage disposal system such as this.

Further recross-examination by Dr. O'Sullivan:

Q. Were you called in consultation here, in advance of
3422 construction, to pass upon these plans and specifications?

A. No; I was asked to examine the plans and go over them and to examine the situation, not in advance of their preparations.

Q. Do you recall your examination of these plans?

A. Yes.

Q. How many by passers are provided for the sewerage before it reaches the disposal works on the Newark meadows?

A. I have to ask you what you mean by by passers.

Q. Is that term unknown to you as a civil engineer?

A. Oh, no, but I do not understand its relationship to these plans.

Q. What is a by-pass as you understand it?

A. There are a great many different kinds; we would have a by-pass for storm water, for the separation of sewage from storm water; we would have a by-pass to carry discharge from one channel to another other than the regular channel, to effect perhaps a different discharge, or to pass through different forms of construction. It just occurs to me that the term, as you use it, is not a term such as we use; I may be in error, but I imagine you mean the number of storm water outlets from the combined systems that would pass into the river, along the lines of this intersecting sewer. Perhaps you didn't mean that, I don't know; I am just guessing at it.

Q. Assuming that is the meaning, have you found in these plans any provisions for by passers which would let the sewage and storm water pass to the Passaic River and into Newark Bay?

A. That is, the discharge of the storm water and sewage within this intercepter?

Q. From the intercepter.

A. None, I don't know of any.

3423 Q. Will you say that there are none in the plans?

A. I don't recall any.

Q. Would not that be an essential matter for you to take into consideration if you had to pass on the adequacy of this whole system?

A. Not at all, I don't think it would affect it at all.

Q. What would be the advantage of a by-passer?

A. We have them along our interceptors for removing the flow temporarily from the interceptor for repairs or examination or some special work that we could not do while the interceptor was working.

Q. And while the sewage is going through the bypass, it receives no treatment, is not that correct?

A. When it goes through the by-pass it does not receive any treatment. That of course is not a constantly recurring or an often recurring condition; that is a condition that would occur at very remote periods, that is I mean we utilize the best conditions of weather and all that sort of thing when we have to resort to such an expedient to get at the work.

Q. In your redirect examination you were asked about trunk sewers; do you know of any trunk sewer that serves more than one community, that has been submitted to you?

A. Oh, yes, I think our trunk sewers in the District of Columbia serve more than one community.

Q. Is that a homogeneous community in the District of Columbia?

A. Well, it is under the same general government.

Q. Is that trunk sewer in esse?

A. Of course, it comes under the same law——

Q. Does it exist now?

A. Oh, yes.

Q. There is a trunk sewer serving the whole of the District of Columbia?

3424 Q. Well, there are several of them built and serving the separate communities within the District. The District of Columbia is not made up of one solidly built-up city, if it were it would be as big as New York.

Q. Does your sewage disposal system take care of the entire sewage of the District of Columbia?

A. Substantially, yes.

Q. Does that differ from a trunk sewer project that serves a large number of communities with varying trade wastes, varying manufacturing interests and differing in location?

A. In the last element, the differing location, I think we have a corresponding condition; the question of different trade wastes does not seem to me to have any effect upon the question.

Q. Have you ever had anything to do directly with trade wastes with regard to sewage disposal?

A. I think I so stated, that we had some trade wastes at Washington, but very little.

Q. Yes, plate printers' ink?

A. And slaughter houses, dyeing houses and plants of that sort; it is not large; it is comparatively small.

Q. I understood you to say it was almost negligible?

A. I may not have caught the gist of yor question.

Q. What I am trying to get at is this:

In the Washington situation you have a homogeneous community with substantially residential sewage; in Boston you have a homogeneous community with trade wastes and with domestic sewage; in the Passaic Valley Trunk Sewer project and you have a large number of radically different manufacturing interests and radically different trade wastes; I asked you if you knew of or had submitted to you any such trunk sewer project for the disposal of such a complex system of waste and sewage?

Mr. Riker: I object to the question on the ground that it contains a number of facts that are not shown to this witness
3425 to have any existence and this question is an expert question or a hypothetical question, the basis of which is not proved in this case.

The Commissioner: Note the objection of defendants' counsel.

A. I have not, but in explanation of that I would like to state that it is not apparent to me, the meaning of the term homogeneous communities as applied to the metropolitan district of Boston and as distinguished from the Passaic Valley District. It appears to me that the two conditions in that respect are very largely, if not precisely identical.

Q. Are there any silk mills in Boston?

A. That I cannot answer.

Q. Are there any woolen mills in Boston?

A. I cannot answer that.

Q. That discharge their trade wastes into the sewage system?

Mr. Riker: If you mean the two are of the same character it is admitted on the record; if you mean to say they are identical that is not admitted.

Q. Are the sewage problems of any two communities identical?

A. Probably not precisely.

Further redirect examination by Mr. Riker:

Q. You were asked about the submission of the plans and specification- of the Passaic Valley Sewerage Commissioners, to you; were they submitted to you for the purpose of getting your judgment or opinion as to the practical application of those plans and specifications or only for the purpose of familiarizing yourself with them for the purpose of testifying in this case?

Dr. O'Sullivan: Objected to as calling for a *physic* process on the part of this witness which is clearly not compatible with the posi-

tion of the witness; he cannot tell by any means known to
3426 the witness what the mental processes of those submitting the plans to him were, what they had in contemplation and what their purpose was.

The Commissioner: Note the objection of complainants' counsel.

A. I was asked to examine those plans in connection with my appearance as a witness in this case.

Q. How long ago?

A. I think about ten days ago.

Q. And that was the time when they were submitted to you?

A. That was the first time.

Q. And your interest in this case is just about ten days' old?

A. Just about.

(A recess was then taken.)

After Recess.

Mr. Riker: I desire to call Mr. Philip.

The Commissioner: Very well, then the witness may take the stand.

ASA HENRY PHILIPS, resumes the stand.

Further direct examination by Mr. Riker:

Q. I have understood from you that you had special occasion for inquiring into the condition surrounding the outfall last September, will you state what they were and what your observations were at that time?

A. Well, I think you refer to a great many trips we made to the outfall with engineers and others who were in Washington attending the Fifteenth International Congress of Hygiene and Demography and in connection with an exhibit at that Congress we had a section of one of our largest trunk sewers, about a half a mile in length, open for inside inspection—station inspection, and we made with our boat—our launch—trips to the outfall taking those
3427 who cared to go to see the conditions there.

Q. Do you know Dr. Soper?

A. I do.

Q. Is he one who went there?

A. He was.

Q. Was the launch high above the water, or——

A. Oh, no, just a gasolene launch, rather low over the water.

Q. Where did you go on that water trip in your launch?

A. We made the trips from the pumping station in the city to the outfall down the river.

Dr. O'Sullivan: What city was this?

Witness: Washington, D. C.

Q. And at the outfall, what did you do?

A. We would bring the boat around as nearly as possible directly

over the five foot diameter pipe which was discharging sewage down in about twenty-eight feet of water so that they could see, with as near-sighted a view as you could possibly have, what the condition was—*sight* and smell.

Q. Was there odor on that trip?

A. There was on one of the trips, yes.

Q. Did you take him over the outfall?

A. We did.

Q. Did you observe any odors at that point at that time?

A. I did not.

Q. Did you see any evidence of suspended particles, solid particles of sewage?

A. No, I think none at all.

Q. Who else was on that trip, will you recall as many as you can?

A. We made quite a good many trips, of course, at various times and I might be astray as to one or two of those who were on that particular trip; I think we had, Mr. Herring, Dr. Soper,
3428 Mr. Webster of Philadelphia, one of Mr. Weber's assistants, and Dr. Tribus, I think he was the consulting engineer for the Borough of Richmond, and perhaps one or two others.

Q. You were asked to give the average age of the sewage that would be discharged from the Passaic Valley Sewage system and I think you said eight hours, about?

A. Yes.

Q. Is that septic sewage?

A. Oh, no.

Q. The intercepting sewers in Washington, are they designed to accom-odate the estimated population at any time or are they designed for a surplus capacity?

A. Always, I think, it is the uniform practise that they are designed for a large surplus capacity. If we take the actual completed capacity of the sewer itself it would be 100% in excess of the actual designed capacity for the necessities.

Q. Have you made observations sufficient in your opinion to justify you in testifying upon the condition of the discharge of sewage in the city of New York along the East River as to whether or not it is in any sense prepared for dilution?

Mr. O'Sullivan: Objected to as calling upon this witness to pass upon his own capacity.

The Commissioner: Note the objection of counsel for the complainant-.

A. I have observed the discharge and it is certainly absolutely unfit and unprepared for a process of disposal by dilution.

Q. What do you observe as to the character of the sludge accumulated in your sedimentation basin at Washington?

A. It contains a very large amount of organic matter. Of course it is not possible to trace all the sources, it is possible to trace one very perceptable source, and that is manure from the streets,
3429 that would be one item; it contains that material which if it were discharged in an unaided state, I mean discharged

without sedimentation, if it passed out into the channel would settle to the bottom of the channel and there build up a solid mass which would have a bad effect in two different ways, it would not only take an undue amount of oxygen out of the water but it would generate objectionable gases which have a tendency very often to bring up masses of this material to the surface, and then forming a deposit of organic matter that is almost, in a way, indestructable; it cannot be reached except it goes through this process of fermentation to break it up, it cannot become broken up and disorganized as organic matter and produces offensive odors, the most objectionable feature altogether of any sewage discharge in water for its dilution.

Q. Is or is not that particular variety of organic matter removed by a process of sedimentation?

A. Yes, sir.

Further recross-examination by Dr. O'Sullivan:

Q. You used the term "septic sewage" in answer to a question of Mr. Riker, will you define what you mean by "septic sewage"?

A. It is what we might term stale sewage, it is sewage in which processes have been begun which create gases perhaps and create objectionable odors; it is offensive sewage, fresh sewage is not offensive.

Q. Do you make any distinction between stale and septic sewage?

A. Not in the sense in which I have just been speaking.

Q. In any sense, as a sanitary engineer?

A. No I do not know that I would.

Q. Is there any one factor that will determine whether sewage is septic or not?

A. One quality of the sewage itself do you mean? I do
3430 not understand what you mean by factor?

Q. How would you determine whether or not sewage was septic?

A. We determine largely by odor and by color, that would be the most ready way to determine.

Q. Sewage could not be septic if it did not have what you describe as offensive odors, is that true?

A. Yes, I would go pretty close to that, I would stand on the odor.

Q. And you make no distinction between stale and septic sewage?

A. No, not in the way in which we are speaking of it.

Q. What is the age of sewage on Manhattan Island as it reaches the discharge point?

A. I suppose the average age is possibly fifteen minutes, something like that, it may be a little more than that but I do not think it is very much.

Q. Would you call it fresh or septic?

A. Oh, fresh. I suppose that ought to be qualified. That is the sewage itself; I doubt very much if the actual discharge into the river, particularly discharges from sewers on Manhattan Island

during the time of rain, where the accumulated sludge deposits that have remained within the sewers are brought out into the river, is fresh sewage by any means.

Q. Do you know what the grade of those sewers is?

A. They are all generally very good grades, the precise figures I do not know.

Q. A pretty high grade so as to have a pretty rapid discharge?

A. But they are tide-locked some of them, they have pretty heavy sludge deposits within the sewers themselves.

Q. Have you ever seen any of those deposits?

A. I have not.

Q. How do you know they have such deposits?

3431 A. I have got most of my information from the reports of the New York Sewage Board.

Q. I do not know of any such board; perhaps you mean the Metropolitan Sewerage Commission.

A. The Metropolitan Sewerage Commission I should have said, yes.

Q. Would the oxygen contents of sewage play any part in its classification?

A. Yes.

Q. Would you expect to find oxygen in fresh sewage?

A. Yes.

Q. Where was the sludge which you spoke of, these sludge deposits that you gave your answer concerning?

A. You mean in the Manhattan sewers?

—. No, in answer to Mr. Riker; I did not get the location.

A. In the sedimentation tanks?

Q. In Washington?

A. In Washington.

Q. Do you make any distinction between the products of ærobic and anærobic decomposition?

A. Yes.

Q. What are the processes of anærobic action?

A. To really give an answer to that is a little more perhaps than I would be willing to undertake, I am not a chemist.

Q. And you are not a bacteriologist?

A. No, sir.

Q. Is sulphurreted hydrogen one of the products of anerobic decomposition?

Mr. Riker: Sewage you mean?

Dr. O'Sullivan: Organic matter.

Q. Can there be any anerobic decomposition of inorganic matter?

A. No, sir, I should say not.

3432 Q. So you understood organic, did you not, when I used the term?

A. Yes, sir.

Q. What effect has sulphuretted hydrogen on shell fish?

A. I do not know, I cannot answer that.

Q. Is not that one of the complaints that has been made by the authorities of Virginia against the sewerage of Washington that sulph-retted hydrogen is destroying the oysters?

A. I never heard of it, no, sir.

Q. The only complaint you heard of was where they suffered some typhoid infection?

A. That was not the complaint, the complaint was altogether due to the condemnation by the Pure Food Board of the Agriculture department.

Q. That these oysters were unfit for food?

A. Yes, sir.

Q. Why?

A. Purely and only, I think, on account of typhoid.

Q. And do you not know the effect of sulphuretted hydrogen upon shell fish?

A. No, sir, I do not.

Q. And sulphuretted hydrogen is one of the products of sludge decomposition, is it not?

A. Yes, sir.

WILLIAM M. BROWN, a witness on behalf of defendants, being duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you reside?

A. In Newark, at present.

Q. What is your profession?

A. Civil Engineer.

Q. Are you a graduate of a university?

A. Brown University.

3433 Q. What class?

A. 1873.

Q. Do you specialize in your profession?

A. My work has been largely in connection with sewerage construction and operation.

Q. Are you a member of any of the scientific societies of this country?

A. The American Society and the Boston Society of Civil Engineers.

Q. In your work of construction and operation of sewers where have you been engaged?

A. In the city of Providence, the city of Boston, on different drainage works, for most of my life on the metropolitan sewerage work of Boston.

Q. How long were you engaged with the metropolitan sewerage commission at Boston.

A. Their work started in 1890 and I was on their work and on the sewerage work until last March.

Q. Have you been in the employ of the State Board of Health of Massachusetts in any connection?

A. I was employed by them on preliminary studies leading up to the Boston metropolitan work.

Q. Any other boards, in that connection?

A. The Massachusetts Drainage board.

Q. You were associated you said from 1890 until last March with that enterprise?

A. Yes, sir.

Q. What positions have you held in that enterprise?

A. I was assistant to the Chief Engineer until 1895 and from 1895 until I came to Newark I was Chief Engineer and had engineering control of the work until I left.

Q. What is your engagement now?

A. I am chief engineer of the Passaic Valley Sewerage
3434 Commissioners.

Q. When did you take that position?

A. Last March.

Q. March, 1912?

A. Yes, sir.

Q. What territory is served by the metropolitan sewerage commission of Massachusetts?

A. The works provide for the main drainage of about 300 square miles of territory surrounding the city and involving parts of the city area.

Q. Does it include any other municipalities or parts of any other municipalities than Boston?

A. It takes in twenty-five.

Q. Do you know what the present population is?

A. Approximately a million, something over nine hundred thousand I think.

Q. Do you know what the cost of the work is up to the present time?

A. Sixteen million dollars.

Q. How is the sewage in this area which you have mentioned disposed of?

A. It is disposed of by dilution in the waters of the outer harbor at points about four and a half miles below the city, two points, one north of the city and one south.

Q. How many actual points of discharge are there, how many outlets?

A. One at each point.

Q. Do you mean by that there are two outlets?

A. Two outlets.

Q. Taking the north outlet, at what tide does the discharge occur?

A. It is continuous, it is discharging all the time.

Q. At the north?

3435 A. And the south the same way.

Q. What is the average daily discharge at the north outlet?

A. About sixty millions, the average, it is as high under flood conditions as 160.

Q. And on the south? What is the character of that discharge?

A. Forty million to the average, and as high as 140 at the maximum, at flood times.

Q. Is there any difference as to the handling of the sewage at these two discharges?

A. Practically the same except that on the north side the discharge is at low water of the harbor and on the south side it is at a point thirty feet below low water of the harbor.

Q. Is there any difference as to detaining the sewage for any period in either of these outlets?

A. It is the same, it is continued.

Q. What process of purification or partial purification is the sewage subjected to in either of these outlets?

A. There is no treatment given to it on either of the discharges. Screens intercept paper and rags or other debris that might be offensively visible in the harbor. None of the sludge or sand or any of the other elements of the sewage are intercepted.

Q. What is the estimated life of the sewers that are now in operation?

A. The North sewer was projected to be competent until 1930, the South side sewer until 1940.

Q. Can you state the maximum combined discharge capacity of these two sewers?

A. The discharge capacity of the South is about four hundred million, on the North about two hundred million.

Q. The North about two and the South about four hundred million?

A. Yes, sir.

3436 Q. As to the outfall itself at the point of discharge into the waters of the bay, is there any difference between the two outlets?

A. There is not except that one is in deep water and the other is at low tide; they are both turned up directly into the bay.

Q. Is there any difference as to the discharge from one outlet or more in either of these systems, do they both discharge from one outlet, in other words?

A. Practically all the time.

Q. What is the depth of discharge at the South outlet?

A. Thirty feet below low water, about forty feet at high tide.

Q. Take the discharge at the South outfall, have you ever visited that outfall?

A. I was there while it was in course of construction and have visited it regularly since, until last March, about once a month.

Q. What has been your observation as to the visibility of the discharge at that outfall?

A. At times it is not visible, it is slightly visible at other times, at low water or slack water.

Q. With respect to odor from the outfall, did you observe odor at that point?

A. There is a very slight odor at times if you get very close to the surface of the sea, it would be practicably unobservable by anyone sailing about, or moving about, the harbor.

Q. How long have these outfalls been in actual operation?
A. The North outlet was put in operation in '95, early in '95, and the other about eight years ago, in 1904.
Q. What is the grade of the Metropolitan sewerage system in Massachusetts, the average grade; does it differ, in the first place, at different points?
3437 A. In the larger sizes it is about one in thirty-five hundred and in the smaller sizes, three or four feet in diameter, it is one in a thousand, something of that kind.
Q. In your opinion what is the average age of the sewage as discharged from the North outlet?
A. I should say it was fifteen hours.
Q. And the South outlet?
A. It is not far from the same age.
Q. Is this sewage septic?
A. I should not call it so, no sir.
Q. Is there any difference in the result, so far as the septic quality of the sewage is concerned whether the sewage is continuously in motion or whether it lies quiet.
A. It septicises more rapidly when it is not in motion I think.
Q. Since you have been associated with the Passaic Valley Sewerage Commissioners have you made an examination of the plans and specifications for the construction of the proposed sewer?
A. I have, I have been over them carefully.
Q. And have familiarized yourself with them?
A. With the details of them, yes.
Q. Do you know what the grades of the different sections are?
A. At the lower end there is a grade of about one in two thousand.
Q. When you speak of the lower end, do you mean from the Pumping Station out to the outfall?
A. No, from the Pumping Station this way.
Q. You are not speaking now of the outfall?
A. No sir.
Q. Do you, as a matter of technical language, call that a sewer or do you call that by some other name?
A. We call that the main intercepting sewer on this side
3438 and below the station, the outfall.
Q. Then when you say the grade is one in three thousand you refer to what part?
A. To the sewer through Newark.
Q. From the Pumping Station or below?
A. From the Pumping Station this side.
Q. Up to what point?
A. I think the grade change is about the Second River, about the upper end of Newark, it comes a little quicker.
Q. Have you made any attempt to determine what will be the probable age of the sewage when discharged at Robbins Reef, the average age?
A. I should say it would be from twelve to fifteen hours, about the same as the Boston Metropolitan sewage.
Q. In your opinion is that or is not that septic sewage?

A. I should call it septic sewage.

Q. Are you familiar with the stipulation between the United States, the State of New Jersey and the Passaic Valley Sewerage Commissioners which is contained in complainant's exhibit No. 135?

A. Yes, sir, I have seen it, I have been over a copy of it. I never saw this paper before.

Q. Look at this paper and see if that is the document you are familiar with?

A. I should say this is the same, that what I have seen was a copy of this.

Q. Directing your thought to the plans and specifications for the Pumping Station, do they or do they not embody the requirements of that stipulation?

A. They do.

Q. In your opinion, will or will not the effluent produced from the works as specified produce the results which are guaranteed in the stipulation which you have before you?

A. I think they will, yes sir.

3439 Q. Have you made a determination in any way of the point of the proposed discharge of this system with reference to the State lines of New York and New Jersey.

A. It is within New Jersey waters but near the State line of New York.

Q. How far from the State line of New York?

A. I never took occasion to measure it on the plan, I should say it was within a half a mile.

Q. As compared with the effluent or the discharge rather into the Boston Harbor from the Massachusetts Metropolitan Sewerage District, what in your opinion is the character of the effluent which will be produced from these works?

A. I think this effluent will be very much more clarified as compared with anything that we handle in Massachusetts.

Q. Why?

A. The grease is practically taken out of it in the septic tanks, and most of the sludge, the sand is intercepted beyond the Pumping Station and practically all the sludge and grease would not be in it that we had in the Massachusetts works.

Q. Will the deeper discharge point have any effect in your opinion?

A. It is ten feet deeper and that will have a considerable effect in taking out, I think, the color and odor.

Q. In your opinion, from your experience with the Metropolitan Sewerage District of Boston, do you or do you not think that the discharge at Robbins Reef will be a safe one?

A. I do, entirely so.

Q. How long do you think it will be a safe one?

A. Say until in the neighborhood of 1940, thirty years.

Q. Are there other devices that you know of which can be introduced into this purifying system which will effect a still greater clarification or purification?

A. Additional tanks might be employed taking out pos-
3440 sibly some more of the sludge or some special grease appliances for taking out any grease that might be left after passing the station and sewage from manufactuories up and down the line might be modified or regulated before it was introduced into the sewer.

Q. What is the character of the discharge in the Massachusetts Metropolitan District in reference to manufacture's waste, do you have it there?

A. Yes, sir, a great deal of it; it is very similar to this section here, there is a large number of large manufacturies of all kinds there, soap works, tanners, bleacheries, dye houses &c.

Q. Do you know whether or not there are acids discharged into the sewers?

A. Some of the sewerage is strongly acid.

Q. Are there any slaughter houses?

A. Yes, sir.

Q. Any silk mills?

A. There are silk mills within my knowledge, and woolen mills.

Q. Tanneries?

A. Tanneries, a great number, yes sir.

Q. Are you familiar with the district that is to be served by this sewer here?

A. I have been over it since last March many times.

Q. Have you made any observations upon the manufacturing industries in this district?

A. We have been into most of the manufactories along the line.

Q. Have you or have you not a corresponding knowledge of the manufacturing industries in the Metropolitan District of Massachusetts?

A. Yes, I should say they are not quite as many as here, but they are in this class, there are a great many of them.

3441 Cross-examination by Dr. O'Sullivan:

Q. I did not quite catch where you pursued your technical studies?

A. Brown University, Providence, R. I.

Q. Did you graduate there?

A. I did.

Q. With what degree?

A. B. P.

Q. What is that degree?

A. That is a technical course connected with the University course.

Q. What does B. P. stand for?

A. Bachelor of Philosophy.

Q. Did you ever graduate as an engineer?

A. No sir.

Q. Did you ever graduate as a chemist?

A. No sir.

Q. Did you ever graduate as a bacteriologist?

A. No sir.

Q. In 1895 you mentioned some connection you had with the Metropolitan sewerage works in Boston; was Mr. Carson your Chief during that time?

A. Prior to that date he was.

Q. Prior to 1895?

A. Yes, sir, he resigned and became engineer of a subway project they had at that date, and I succeeded him in the control of the works.

Q. Didn't you resign first, during your connection with Mr. Carson and with the Metropolitan Sewerage Works in Boston?

A. I did for a short time, part of a year, and was employed by the State Board of Health on their water project.

Q. Was that resignation due to any misunderstanding with Mr. Carson.

3442 A. I do not think it was; I do not know that it was.

Q. Do you recall the occasion of your resigning?

A. Yes sir.

Q. Where did you have any experience outside of the sewage and sewerage systems that discharged into Boston Harbor?

A. In what way do you mean?

Q. As an engineer?

A. I advised with the several commissioners who projected this project, I think I was there six or seven times; I think it was with the first commission who recommended the disposal at this point.

Q. And the scheme then was to discharge it crude was it not?

A. Yes sir.

Q. When did you first begin to practice as a civil engineer?

A. Immediately after leaving school I was employed by the City of Providence.

Q. Although you had not taken the technical course of Civil Engineer?

A. No sir.

Q. Have you been connected with any sewerage system or sewage disposal system other than that discharged into the Boston Harbor?

A. I was connected with this in its early history a number of times.

Q. You were called in, to consult with?

A. I was with the original commission who projected this, I was a member of that original commission, the commission consisted of Mr. Herring, Mr. Croes and myself.

Q. Did you come on from Boston then for that purpose?

A. I was here covering a period of four or five months, I was here once a week or some such matter.

Q. What particular feature of the investigation or collec-

3443 tion of data upon which that commission acted were you engaged in?

A. I suggested the method of passing under Newark Bay and thus reaching the harbor.

Q. Why?

A. I don't know why; they asked me to and I did.

Q. In other words you did what they suggested?

A. No, I think I suggested the method.

Q. Why did you want it discharged into New York Bay rather than into Newark Bay?

A. In my judgment it was the finest volume of water for discharge for this and other territory in this vicinity.

Q. What harm did you think it would do to Newark Bay?

A. Newark Bay was of much smaller tidal volume and it was much more shallow; the tidal volume and the velocity were much less.

Q. Had any borings been made at that time of Newark Bay to determine the feasibility of carrying it under Newark Bay and into New York Bay?

A. I do not recall whether there were borings at that time or not.

Q. Have any other borings been made at any time during your connection with the original commission?

A. There was a study by a man named Owen who was called on to advise about it, and instead of accepting his project we recommended it be taken over to this larger tidal volume of New York Bay.

Q. Was he a geologist?

A. I think he was a county engineer, James Owen.

Q. Are you aware of any borings that have been made by geologists to determine the feasibility of making a tunnel under these two bodies of water that would transport this sewage?

A. There were a variety of deep borings made by the present Passaic Valley Sewage Commissioners, they go down much
3444 below any depth they have projected to drive their work.

Q. Who made the borings, do you know?

A. I could not say what contractor; the cores are filed in the archives of the commission.

Q. Were they wash borings or otherwise?

A. They were wash borings down to the rock and the rock was drilled for a long distance, I should say perhaps one hundred feet.

Q. What rock did they strike?

A. They struck largely limestone.

Q. At what depth?

A. I think about forty feet below the bed of the bay.

Q. Are you quite sure about that Mr. Brown?

A. No I am not, I told you, I think. It is a matter of record on the plans of the Board, but they struck, below the sludge of the bed of the bay, something like a hard pan, clay and rock, and below that they struck sand stone and they took a great number of borings in it, enough to develope in my judgment the character of the rock very fully.

Q. How deep down did they go in their borings?

A. I say I think about 100 feet into the rock.

Q. Will you state positively that they did not go over 160 feet?

A. I will not; I told you I thought so.

Mr. Riker: It is utterly immaterial whether it was — not and I object to this line of questions as not cross examination and as immaterial and irrelevant.

The Commissioner: Note the objection of defendants' counsel.

Q. Are you engineer now employed by Passaic Valley Sewerage Commissioners?

A. I am.

Q. And you have charge of this construction work?

A. Yes sir.

3445 Q. And part of that construction work in this tunnel that is presumed to carry the effluent from the disposal works on the Newark Meadows out to Robbins Reef or a point near to it?

A. It may be part of the project, yes sir.

Q. It is important for me to know; if it is not part of the project I will stop right away, that ends my interest in the suit. If Mr. Riker will assure that is not part of the project, I am ready to stop now.

Mr. Riker: Why argue; go on and ask your questions and Mr. Brown will answer them if he can and I will make such objections as I see fit. That is about all there is to that; I am not trying your case nor do I desire to.

Q. Have you considered the feasibility of constructing such a tunnel at all?

A. I have, yes, sir.

Q. Would it be necessary, in considering the feasibility, for you to know the character of the material through which the tunnel would be bored?

Mr. Riker: Objected to on the ground that it is not cross examination and that it is not material or relevant to the inquiry.

The Commissioner: Note the objection of counsel for the defendant.

Dr. O'Sullivan: Complainant's counsel presses the question as being a material one because if it were an unfit material the sewage effluent would escape before coming to the discharge pipes that are so elaborately described in the plans of the Passaic Valley Sewerage Commissioners.

Mr. Riker: I do not see how that concerns the complainant; whether it did or not it would be within the territory of the

3446 State of New Jersey.

A. It would be desirable to know it, yes sir.

Q. What efforts have you made to acquire knowledge on that subject?

Mr. Riker: Objected to as not cross examination and not relevant or material.

The Commissioner: Note the objection of Counsel for the defendants.

A. I have made no further effort except to examine the preliminary studies of the Board.

Q. How deep under Newark Bay will the tunnel be?

A. I don't know.

Q. You used the term "septic tank" in answer to a question of Mr. Riker; does the Passaic Valley Sewerage Disposal System contemplate the use of a septic tank in the sewage disposal works?

Mr. Riker: I submit that the words "septic tank" were not used at all and I object on that ground. If I am wrong in my recollection, the record will show.

The Commissioner: Note the objection of the counsel for defendants.

A. I did not intend to refer to a septic tank, the tanks projected are all open tanks, sedimentation tanks.

Q. Do you recall using the term "septic tank"?

A. I do not; it was a mistake if I used it, there is no septic tank projected.

Q. Do you recall using the term "septic sewage"?

A. I think I did say septic sewage, I think Mr. Riker asked me if in my judgment the sewage of the metropolitan system was septic.

Q. You described the multiple outlets through which this effluent is to be discharged; have you any experience or have you
3447 had any experience with multiple outlets?

A. The outlets that I have built have been single outlets.

Q. What study have you given to New York Upper Bay and contemplated sewage discharges into New York Upper Bay and its capacity for digesting or assimilating such sewage?

A. Practically nothing of recent date.

Q. What knowledge have you of the current and movements of water in New York Harbor?

A. Very little.

Q. Have you studied this sewage disposal scheme for disposing of the sewage of the Passaic Valley as it is projected?

A. I went into it very carefully in '97; the project was not materially different at that time.

Q. When was the last report by the Passaic Valley Sewerage Commission on these contemplated works?

A. It was not made by me and I could not tell you, I think it was about 1908.

Q. Has any report, to your knowledge, been made since 1908 by the Passaic Valley Sewerage Commissioners?

A. Not within my knowledge.

Q. Have the plans and specifications been materially changed from those contemplated in the year 1908 by the Passaic Valley Sewerage Commissioners?

A. I do not think they have, no, sir.

Q. Have you seen the plans as designed by Mr. Edlow Harrison and Mr. William Gaven Taylor and dated December 1, 1910?

A. I have, yes, sir.

Q. Will you look at complainant's exhibit #135 and see whether the scheme for securing the effluent described in that stipulation in any way materially differs from the plans designed by Mr. Harrison and Mr. Taylor in 1910?

3448 A. I do not think it does.

Q. When was that stipulation executed, Mr. Brown?

A. October, 1909 is the date on the first page.

Q. Look at the latter part of the instrument.

A. April 14, 1910.

Q. Were the plans completed to procure the stipulated effluent in that exhibit, complainant's exhibit #135, at the time of the execution of the stipulation by the respective agents of the Federal government and the State of New Jersey?

A. I was not here, I could not tell; I believe they were, though.

Q. Were you in the room when I was asking Mr. Phillips about the *bi*-passes on the intercepting sewers?

A. I think I was, I was sitting over there, I think.

Q. How many *bi*-passers are there in *this* intercepting sewers before you reach the disposal works?

A. I do not know exactly what you mean by passers; if you mean overflows from existing sewers, there are about fifty.

Q. Is that a new term to you, *bi*-passers?

A. It is on such a structure as this.

Q. Do you know of that term in any relation when used by civil engineers?

A. A *bi*-pass is a channel which turns a flow around some existing structure or object of some kind; those you refer to simply turn the sewage from one direction and flush it into a channel flowing in some other direction, that is all.

Q. Is there any provision in the Passaic Valley trunk sewer project for the turning of the sewage into the Passaic River on occasions or into the Newark Bay on occasions?

Mr. Riker: Objected to as immaterial and irrelevant, having nothing to do with the issue and not cross examination.

3449 The Commissioner: Note the objection of counsel for the defendant.

Dr. O'Sullivan: That is for the purpose of showing that it is the intention of the Passaic Valley Trunk sewer project and of the Passaic Valley Sewerage Commissioners to turn this sewage on many occasions into the Passaic River and into the Newark Bay, thereby defeating the very object for which the trunk sewer scheme is designed.

Mr. Riker: The suggestion of counsel for the complainants appears to be absolutely impertinent to the issues because it does not concern the State of New York what happens to the sewerage as far as the discharge into Newark Bay or Passaic River is concerned.

A. I do not think so, no, sir.

Q. Do you know positively whether there are or not?

A. There are not; there are provisions for turning some small part of it. All separate sewage is intercepted without overflowing.

Q. Does the system become a separate one or a combined one in the proposed sewer?

A. It is intended to take all the separate sewage and part of the combined sewage.

Q. How do you determine which of these you will let loose into the Passaic River or Newark Bay?

A. If the sewers have been flooded by storm it has to go into the river, our structure is not large enough to take the whole storm

flow and the sewage from this whole area, we can only take a very small part of it.

Q. Are these bi-passers designed to prevent flooding of the sewage disposal system?

Mr. Riker: Objected to on the ground that the witness
3450 says there are no bi-passers.

The Commissioner: Note the objection of the defendants' counsel.

A. Intended to exclude storm water from the intercepting sewer.

Q. Before reaching these bi-passers are the storm water and sewage and trade wastes combined in the intercepting sewers?

A. Yes, sir, they are in many of them, in some of them they are not.

Q. In those in which they are combined, how do you separate by a bipasser storm water from trade waste and sewage?

Mr. Riker: Objected to as not cross examination, immaterial and irrelevant.

The Commissioner: Note the objection of defendants' counsel.

A. An aperture is made in the side of the combined sewer, a small passage is led from that to the intercepting sewer and that is closed automatically by a regulating device, so called, a valve that shuts it up.

Q. And now the part of the material which escapes from the intercepting sewer is a combination of sewerage, trade waste and storm water, is it not?

A. It is the ordinary house sewage very largely, diluted with storm water.

Q. And why not the trade wastes?

A. The trade wastes, if in the combined sewer, are diluted in the same way.

Q. What term do you apply to this point of egress for the sewage into the Passaic River and into the Newark Bay if you do not use the term bi-passers?

A. We call them outlets.

3451 Q. How do you define septic sewage?

A. Sewage that gives an odor.

Q. If it had no odor would you determine that it was not septic?

A. Practically we would call it sewage that is not septic, technically I presume any sewage is septic after it begins to be put in the sewer and runs; it has no practical septicisation, though for a number of hours after it is in the sewer.

Q. Do you recognize such distinction for sewage as fresh, stale and septic?

A. Stale sewage is known to me as sewage of say a day's age; septic sewage, after it begins to be very odorous; fresh sewage up to something like twenty hours—fifteen or twenty hours—in the sewer.

Q. Do you measure it entirely in terms of time?

A. I do myself; there are other methods of measuring; chemists, biologists and others measure it by other means.

Q. Do you recognize that septic sewage may be highly septicized and yet not give off offensive odors?

A. I do, yes, sir.

Q. Have you read any works on septic sewage?

A. I have, yes, sir.

Q. Are you familiar with Mr. Fuller's works?

A. I am, I own a volume, yes, sir.

Q. Let me see if you will agree with his definitions of fresh, stale and septic sewage. I read from page 70 of Mr. Fuller's work on septic disposal: "Sewage at first contains free oxygen and nitrogen in the form of nitrates and nitrites and the proportion of organic matters in suspension is comparatively large. Such a liquid we call fresh sewage." Would you apply that definition to fresh sewage?

3452 A. I would make no objection to it.

Q. I ask you if you would accept it?

Mr. Riker: He has answered it.

Q. Will you give me your definition of fresh sewage?

A. I told you sewage running in the sewer up to twenty hours or more, such a matter as that.

Q. Even though septicization had taken place?

A. Septicization on the terms as you outline it, yes.

Q. Mr. Fuller describes stale sewage as—"sewage when its free oxygen has just become exhausted and its free ammonia increased to the maximum possible by the exhaustion of its oxygen, we designate as stale sewage." Do you accept that definition?

Mr. Riker: Objected on the ground that it has not appeared in evidence that any such definition was given by anybody.

The Commissioner: Note the objection of the counsel for the defendant.

A. I do not object to it, he can make any definition he wants to, that is something I am not responsible for in any way.

Q. Could sewage be stale that had plenty of oxygen?

A. If sewage had a large amount of oxygen I do not think it would be very stale, no, sir.

Q. But with you these distinctions are drawn in terms of time entirely and have no relation to nitrogen, oxygen, free ammonia or any other constituent elements of sewage?

A. No, sir.

Q. Do you know whether there would be more organic matter held in solution by the liquid portions of sewage when the sewage is septic or when the sewage is fresh?

A. I do not, no, sir.

3453 Q. Has any provision been made in the stipulation as shown in complainant's exhibit #135 to eliminate organic matter in solution?

Mr. Riker: Question objected to on the ground that the exhibit speaks for itself.

The Commissioner: Note the objection of defendants' counsel.

A. I do not know about that, I am not prepared to testify.
Q. What organic matters are held in solution?
A. I do not know, I am not a chemist, I am not a chemical expert.
Q. What colloidal matters are held in solution?
A. I do not know, I am not a chemist.
Q. What provision is made in the stipulation to exclude pathogenic germs from the effluent you propose to discharge into New York Bay near Robbins Reef?

Mr. Riker: Objected to on the same ground, that the exhibit speaks for itself.
The Commissioner: Note the objection of the counsel for the defendant-.

A. I do not know.

Redirect examination by Mr. Riker:

Q. You have stated that you were concerned in the original project, on the original commission?
A. Yes, sir.
Q. What treatment was the effluent of the sewage to receive under that plan?
A. Rough screening and continuous discharge from one outlet.
Q. Do you think that such a discharge, treated by rough screening, at Robbins Reef, would create a nuisance?
A. I do not, no, sir.
Q. Do you base that opinion on any experience and if so, 3454 where?
A. On the experience I had with the Massachusetts outfalls.
Q. Why have you not taken into consideration the tides and currents in New York Bay as bearing on this question?
A. The tidal volume was so great and the known velocity was so ample that it was not necessary to make a detailed study of the tidal volumes.

Recross-examination by Dr. O'Sullivan:

Q. How much dilution is there now in New York Upper Bay?
A. I do not know.
Q. What portion of the flood on each flood tide consists of water that has already been in the harbor and been diluted heavily?
A. I do not know.
Q. And yet are not these necessary for you to know when you are entertaining the question of solution?
A. I do not think so.
Q. No matter how polluted the water was it was unnecessary for you to know as a basis for determining the question of the effect of the dilution from the Passaic Valley sewage to be discharged into it?
A. I did not say that, I said I did not know what the pollution of New York Bay was.

Q. Does sewage discharged into tidal waters cause greater pollution than the deposit from the bottom of those waters?
A. I do not know what you mean by your question.
Q. (Last question read to witness.)
A. I do not know what that means.

Mr. Riker: Counsel for the defendants objects on the grounds that he does not know what that means.
The Commissioner: Note the objection of defendants' counsel.

3455 Q. Do you make a distinction between sewage and sewage deposits?
A. There is a deposit from sewage, a sludge deposit from sewage, if it loses its velocity it gives it up in any channel it may be running in.
Q. Do you make a distinction between sewage and sludge?
A. Sludge is a product of sewage as I understand it.
Q. Do you make a distinction between the two or do you use them as synonymous?

Mr. Riker: Objected to on the ground that witness has already answered that he does make a distinction.
The Commissioner: Note the objection of counsel for the defendants.

A. Ordinary house sewage carries sludge with it, there is sludge in the sewage.
Q. By what name do you describe the deposits in tidal waters that have been made there by sewage?
A. They are sometimes referred to as mud.
Q. Do you ever use the term sludge?
A. I never have, no, sir.
Q. And by mud you mean the deposit from sewage?
A. I say it is sometimes alluded to as mud.
Q. Do you use that term?
A. No, sir.
Q. What term do you use?
A. I have not used any because we do not have it where I was.
Q. In Boston?
A. Yes, sir.
Q. Have there not been complaints made by some of the federal authorities there and have they not been directed to have their outfall removed from its present position in Boston Harbor?
3456 A. I have not heard of it.
Q. Is it not a fact?

Mr. Riker: How can he answer that when he says he has not heard of it?

Q. I now ask you if this mud, sludge or sewage deposits, by whatever name you describe it, will pollute water to a greater extent than the sewage discharged into those waters?
A. I could not say, sir, I do not know.
Q. Mr. Riker asked you whether you had been in the original

project to run a trunk sewer into New York Upper Bay and discharge this crude sewage and you said you had.

A. I was one of the commission that recommended the discharge in New York Bay off Robbins Reef?

Q. Of crude sewage?

A. Yes, sir.

Q. And you still think that would be a good idea?

A. I do, I think that is the best disposal for this district.

Q. The most economical, too?

A. I do not say that.

Q. Who was the senior member of the commission on which you served and which recommended that project?

A. Rudolph Herring.

Q. Do you know whether or not he has since condemned that scheme and even the present scheme of sewage disposal adopted by the Passaic Valley Sewerage Commissioners?

Mr. Riker: Question objected to on the ground that it is impertinent, is not cross-examination and is not competent, and counsel directs the witness not to answer.

The Commissioner: Note the objection of counsel for the defendants.

A. He never in my presence objected to it, whether he
3457 has or not is unknown to me.

Q. How recently have you seen Mr. Herring?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of the counsel for the defendants.

A. I saw him within a year I think.

Q. Have you discussed the Passaic Valley trunk project with him?

A. Not particularly.

Q. Did you discuss the Imhoff tank system with him?

A. I don't think I did, no, sir.

The further taking of testimony in behalf of the defendants was then adjourned until Tuesday, the 31st day of December, 1912, at 10:30 o'clock a. m. at the office of Messrs. Riker and Riker, in the city of Newark, N. J.

3458 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker & Riker, Newark, N. J., Tuesday, December 31st, 1912.

Before James D. Maher, Esquire, Commissioner.

Appearances:

Thomas Carmody, Esq., Attorney General of the State of New York; William A. McQuaid, Esq., Deputy Attorney General; Dr. William J. O'Sullivan, Special Counsel, for the People of the State of New York, Complainants.

Edmund Wilson, Esq., Attorney General of the State of New Jersey; Robert H. McCarter, Esq., of Counsel for the State of New Jersey; Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

HENRY MARTYN ROBERT, a witness on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you reside, General?

3459 A. In Owego, New York.

Q. Will you state your profession and your professional training and experience?

A. I am an officer in the U. S. Army; I was educated at the Military Academy at West Point, N. Y., in 1855-57. I graduated and entered the corps of engineers in 1857, remaining in that until my retirement as chief of the corps in 1901. I served as instructor at West Point in mathematics and natural philosophy and afterwards as a member of the faculty, at the head of the department of practical military engineering, from '65 to '67. During the Civil War I served as an engineer and officer until my health broke down and I was engaged on fortification work, the construction of fortifications. Since that time I have been upon various engineering duties in charge of river and harbor improvements and light house construction and fortification work on the Pacific coast, the Atlantic coast and on the lakes. I also served as engineer commissioner for the District of Columbia, from 1895 to 1901 I was president of the Board of Engineers for fortifications, of the New York Harbor Line Board, the Philadelphia Harbor Line Board, and the examination of engineer officers for promotion and of the Board of visitors of the engineering School of Application for the training of engineer officers.

Q. What opportunity have you had for the observation of different harbors in the United States?

A. I have been stationed at various harbors during most of this time, such as New York, Philadelphia, San Francisco, Portland, Oregon and so forth and have had to make the study of various harbors that I have either been in charge of or a member of the Board designing such harbors such as Galveston, Pensacola, the mouth of the Mississippi, the Harbor of Los Angeles and so forth.

Q. What opportunities have you had for observing the
3460 conditions in New York Harbor, General?

A. I was stationed in New York City, with my office in the Army Building, from 1893 until 1901; during that time in the summer I resided for three summers, and also for two winters, at Fort Wadsworth, just below the Narrows, or at the Narrows and had opportunities to see the condition of the Harbor such as anyone would, passing constantly over the ferries and also from attempting to use a bathing house we had on the place.

Q. Did you have any official connection with the Harbor Board Line outside of that of member?

A. I was President of the New York Line Harbor Board from 1895 to 1901.

Q. Did the matter of the plans of the Passaic Valley Sewerage Commissioners come before you in your official capacity at any time?

A. Yes, in 1897.

Q. Do you remember where the proposed outfall or outlet of the sewer was at that time?

A. Merely that it was in Newark Bay.

Q. Will you state your own observation of the character of the waters in New York Harbor and your knowledge of the quantity of the Harbor water and the periods required for the displacement of the waters by fresh sea water and fresh land water?

A. What was the first part of that question?

Q. Your particular observation of the character of the waters in New York Harbor?

A. I was struck with one thing, that the beach just below Fort Wadsworth where I resided was very much interfered with by the deposit on it of dead animals and so forth, so that I, after probably two attempts, stopped using a fine bathing house we had
3461 there. But I understood that this material did not come right from the sewage, direct, but was blown in there, I was told, from the outside, from the deposits made by the New York authorities.

Dr. O'Sullivan: I object to the witness stating mere hearsay, what he heard.

The Commissioner: Note the objection of counsel for the complainants.

Witness: This was a nuisance, there is no question but that was a nuisance. As to what caused it I do not know, but I should say that it was, as my recollection is, always connected with the wind

that blew from the sea, whenever these disturbances occur-ed. At other times the bathing place was all right. That was all the opportunity I ever had for observing these things; I never made any chemical test nor any examination of the waters in that way.

Q. When was it you observed these deposits on the beach?

A. In '93, '4 and '5, the summers of '93, '4 and '5.

Q. Have you any knowledge of the quantity of water in the upper Bay and the period required for its displacement by fresh sea water?

A. There is roughly about fourteen thousand million cubic feet, as I understand; in the upper bay, and the amount going through on a tide is pretty nearly as great as that, as far as I can see, that the amount going out at the Narrows is pretty nearly as great as the contents of the bay. But it does not go out to sea, but is returned, a great part of it, into the bay, with that oscillation, and the rate of its movement is such that it would take several days for it to get out, so as not to return again.

Q. Are you familiar with the stipulation between the United States, the State of New Jersey and the Passaic Valley Sewerage Commissioners?

3462 A. I have read it over somewhat carefully sir.

Q. What is your opinion of the effect of the discharge of an effluent produced as described in the stipulation in question upon the waters of Upper New York Bay?

A. Of course it will add to the pollution of the bay. My opinion is that treated as described it would not injure it seriously provided that from other sources it was not polluted too much. That is, you take the present pollution as an example and put into it what is to come from this sewage project and I would not regard it as making that so as to create a nuisance.

Q. Have you attempted to determine what the probable effect of this discharge as described in the stipulation would be over a period of years when the population of the district shall have increased?

A. Yes sir. I would perhaps put in this way what has occur-ed to me:—Suppose there was a population of ten million people using the ordinary average of one hundred gallons of sewage per person, we would have one thousand million gallons of sewage per day to take care of. The flow of the Narrows would be approximately during the day, the two tides, twenty-eight thousand million cubic feet, which would amount to over two hundred thousand million gallons, or, in other words, the amount of water going out is two hundred times as much as the sewage. If it all went out to the sea and none was returned the sewage would be very much diluted. Allowing that it took six days to get rid of the whole of that sewage, in other words allowing it was six times as strong as that, there would be about thirty times as much water as sewage; in other words the sewage would be approximately three per cent the amount of water that dilutes it. The sewage itself, taken as the strength that is generally considered as the average of American sewage,

that is, one part organic matter to a thousand of water,
3463 would be diluted so that there would be one part organic matter to about thirty-three thousand of water. It does not seem to me that such sewage would prove a nuisance. Furthermore, I think that sewage is taken a great deal stronger than the Passaic Valley sewage would be under the agreement with the United States Government. I notice that the English standard sewage is put down as less than one-third the strength of American and I think that the agreement with the United States Government requires the Passaic Valley Sewerage Commissioners to take such steps as would reduce this sewage away below the ordinary American standard and more nearly to the English.

Q. Now General, when you were testifying as to the time when there might be ten million inhabitants using this bay to discharge sewage into, were you considering the sewage as the standard American sewage?

A. Yes, sir.

Q. Even at that, is it your opinion that with a population of ten million the waters of the bay would become a nuisance from the discharge of sewage from that number of inhabitants?

A. Provided that sewage is not in large particles and so forth, provided it goes through small sieves and so forth and is reduced in that way and is disposed of like your agreement requires, where the current is strong and deep, I would not think so, sir; that is, in the bay, we are talking about New York Bay.

Cross-examination by Dr. O'Sullivan:

Q. Did you ever make any chemical examination of the waters of New York upper bay?

A. No sir.

Q. Did you ever make any bacteriological examination of the waters of Upper New York Bay?

3464 A. No sir.

Q. Have you ever been in charge of a sewage disposal system?

A. I have had nothing to do with sewage, I am not a sewage expert.

Q. Are you familiar with the Passaic Valley Water Shed?

A. I would say no sir, nothing but just the general knowledge that everybody has.

Q. Have you any knowledge, General, of the amount of deposit of sewage matters in the waters of the upper bay?

A. You mean New York Upper Bay?

Q. New York Upper Bay.

A. I understand there is a great deal, sir; I only know it from reading, that there is a great deal, and especially near the shores.

Q. Do you regard these sewage deposits, General, as a more prolific source of pollution than the fresh sewage discharged into these tidal waters?

A. My opinion would be worth nothing on that, sir, I really don't know sir.

Q. What index, General, do you take to measure the capacity of waters to receive sewage discharges?

A. As I stated sir, I am not an expert at all on that matter and come to it purely from the position of a harbor engineer having had to design a good many of the harbors of the United States and having to look out for them with respect to the interference with channels more particularly and am not an authority on these matters to which you refer; my opinion would really be worthless upon them if I had any at all.

Q. Why do you take one hundred gallons of sewage per capita as a fair average for the Passaic Valley district?

A. I take that, not for the Passaic Valley District alone, I take it for the whole of New York and the vicinity and I took
3465 it simply because I found in reading the matter up that was usually assumed to be about what was used except in the manufacturing districts where they use rather more. But where they did not use it I found that the English authorities—at least, by looking at the Encyclopedia Britannica, I found they did not allow as much as that in England.

Q. Will you name some city in the United States where the average sewage per capita is less than a hundred and fifty gallons?

A. I have never looked into that question; I found that the average sewage of England was taken at thirty gallons of water per inhabitant.

Q. Do you realize, General, that the English do not bathe and use as much water as we do in bathing and for other purposes?

A. I know they do not use as much water, as I have had something to do with the water-works, a little, occasionally; they do not use anything like as much water as we do, I did not know the other about bathing, I rather thought they were a little ahead of us on that.

Q. You were talking about the tidal prism of New York Upper Bay; will you state please what means you adopted to measure the volume of the tidal prism?

A. I did not measure it, I took simply the coast survey and the other estimates, and today I happened to see an estimate of the Metropolitan Board, and they all practically agree as to the amount of water of the ebb-tide passing through the Narrows; that is what I have taken as the figure.

Q. What percentage of the water that leaves the upper bay on the ebb returns on the flood into the upper bay and into the East River and the Hudson River?

A. I think somewhere about ninety percent, approximately.

Q. Your examination- of the condition of the waters of
3466 the upper bay, I understand, were confined to such observations as you made from ferries?

A. Oh yes; I made no observations of that sir, I had no duty that made it necessary for me to observe that class of thing.

Q. And these deposits that you found near the bath house, came from the outer water you say, from the ocean?

A. That is what was said, and the nature of the wind and so

forth led me to think so, and I also could not conceive of New York allowing such things to go through the sewers.

Q. Do you realize, General, that all the sewage from Manhattan Island is very fresh sewage?

A. Yes sir.

Q. Within a half an hour old?

A. Yes sir.

Q. And you realize that such sewage is disintegrated by biological action?

A. Yes sir.

Q. As to the character of the Passaic Valley sewage, the sewage that is now being discharged into the Passaic River, have you any knowledge of that?

A. No sir, not at present.

Q. You do know, as a general proposition, that it is very rich in organic matters due to the character of some of the trade waste?

A. Yes.

Q. And that these organic matters are in solution?

A. Yes.

Q. Have you read the scheme projected for the procuring of the effluent which is guaranteed in the stipulation as set forth in complainant's exhibit No. 135?

A. I have read what purports to be a printed copy of it.

3467 Q. And it consists in coarse screening and sedimentation, am I right, sir.

A. Yes sir; there are two screenings as I recollect, the coarse screens, and then, what are termed here fine screens, but they are four-tenths of an inch.

Q. Which is rather a coarse screen, would you say?

A. It could be finer, sir—they might be finer to advantage and the United States Government could require that to be done provided it was found that was not fine enough.

Q. How old would you think that sewage would be by the time it reached the outfall, General? The sewage contemplated to be discharged by the Passaic Valley Trunk Sewer?

A. This would be purely a guess, sir, I have not looked into that matter of how long it would take; I have not examined the details sufficiently, really, to be able to tell how long it would take from the upper—I suppose you mean from the upper point, like Passaic?

Q. Yes.

A. Because it would vary as you go along. I really would not like to express an opinion, it would be a pure guess unless I stopped to work out something on it, sir.

Q. Do you regard the Trunk Sewer as approximately twenty-six miles long?

A. I do not understand that question, sir.

Q. Do you know whether or not the trunk sewer contemplated to be built by the Passaic Valley Sewerage Commissioners is approximately twenty-six miles long?

A. I understand it to be about that length.

Q. And that the grade is rather light?

A. Not very great, sir, I do not recollect what it is.

Q. And that sewage transported from Paterson would take fifteen to eighteen hours to reach the sewage disposal works contemplated to be built on the Newark Meadows?

3468 A. I have not looked into that, sir.

Q. You do realize that much of that sewage would be practically matter in solution when it reached the detention tank and sewage works?

A. I should suppose so.

Q. Is there any provision in the stipulation and in the scheme for purifying the sewage that would eliminate those organic matters which would be held in solution?

A. No sir.

Q. Do you know, General, that there is colloidal matter incident to the trade wastes of the Passaic Valley manufacturing plants?

A. No sir, I do not know anything in regard to that, I have not looked into the question of the manufacturing plants.

Q. Is there any provision in the stipulation as set forth in complainant's exhibit No. 135 that will eliminate these colloidal matters from the effluent contemplated to be discharged into the New York Upper Bay?

A. There is not, sir, as far as I know.

Q. Is there any provision in the purification scheme for the elimination of pathogenic germs from the effluent contemplated to be discharged into New York Upper Bay?

A. No sir.

Q. As to Putrescibility, will the solid organic matter or the organic matter in solution be most prutricible?

A. The solid matter or that in solution?

A. Yes.

A. I don't know sir: I might have an opinion, but it would not be worth anything, I do not know.

Q. Will septic sewage deprive tidal waters into which it is discharged of their oxygen contents more readily than fresh sewage.

A. I don't know that, sir.

Q. Your calculation of the amount of dilution that would

3469 probably take place when the population amount to ten million is predicated entirely on the sewage per capita not exceeding one hundred gallons?

A. That calculation is based on that, sir.

Q. And that calculation would not hold if it was shown that the sewage per capita was greater than one hundred and twenty-five gallons per capita?

A. You would simply, in that case, have to take eighty per cent of it.

Q. And in case it was shown to be two hundred and eighteen gallons per capita, in the same ratio you would diminish the percentage of dilution?

A. Yes sir.

Q. Do you know of any reason why sewage effluent such as

stipulated for in complainant's exhibit No. 135 should not be discharged into Newark Bay?

A. Yes.

Q. Why, General?

A. The amount of mineral matter in suspension in that sewage, supposing it to be at the average I spoke of, one part of mineral matter to one thousand of water, would be so much in the course of the year to interfer- very greatly with the navigable channels?

Q. So that, from the effluent as stipualted in complainant's exhibit No. 135 you would expect sufficient matter to be deposited so that it would to some extent interfere with navigation?

A. In Newark Bay, quite seriously.

Q. Have you made any approximate estimate of what the amount of deposit would be likely to be?

A. The project provides for an approximate discharge of about forty-five million cubic feet of sewage per day which estimated simply at the weight of water, would amount to about twenty-eight million pounds, which would amount at least to twelve hun-
3470 dred cubic yards of solid deposit per day, or, during the year, to over four hundred thousand *yards* cubic yards of deposit. The entrance to Newark Bay is quite shallow and the deposit of nearly half a million cubic yards each year of solid matter there would mean a great deal of injury to the channel.

Q. The deposit which you have just testified to, as, in the course of probability being likely to be deposited, relates to the deposit that you expect from the sewage effluent stipulated for in Complainants' Exhibit No. 135?

A. It would be the maximum; I would not expect so much as that, sir.

Q. But approximately that much.

A. I would feel that it might be from half that amount to that amount.

Q. From the sewage effluent stipulated for in Complainants' Exhibit No. 135?

A. Yes, sir.

Q. You have stated, General, what deposit you would expect from the sewage effluent guaranteed or stipulated for in Complainants' Exhibit No. 135, and as I understand it relates to the mineral matter?

A. Yes, sir.

Q. What would you estimate the deposit to be from the finer organic particles in that stipulated effluent?

A. I could not estimate on that.

Q. Approximately?

A. I really have no idea of how much that would be. Assuming as I do that the statements of the standard sewage in the ordinary authorities are correct, and that this sewage is only in that condition—of the standard—there would be an equal amount of organic matter,—an amount of organic matter equal to the other; but I presume that that would be very soon dissolved or devoured by
3471 the life, the fishes and so forth, and that there would not be so much of that deposit—there would not be much of that deposit near by.

Q. In order to get some approximate idea of the amount of deposits that you would expect from the organic particles in the effluent guaranteed or stipulated for in Complainants' Exhibit No. 135, would you state as to whether it might be one-half as much as the other or one-quarter as much?

A. I would not expect it to be either, sir.

Q. Even less than a quarter?

A. Oh, yes, sir.

Q. How much less, can you give me an idea General?

A. No, sir, I would simply say, never having studied that proposition, that I really have no opinion upon it excepting the general idea that it would not be a very large deposit there.

Q. As compared with the mineral deposit?

A. Yes, sir.

Q. Did you make any estimate of the coloidal matters that would be deposited when meeting sea water that would act as a precipitant upon the sewage in the effluent guaranteed in Complainants' Exhibit #135?

A. No, sir.

Q. Would you give an approximate idea of how much you would expect the deposit to be in proportion to the amount of *u*norganic matter?

A. I do not know, sir, at all, I really have no opinion upon the subject, as it is a matter which I have never examined.

Q. But you would expect deposits of both of these matters to some extent, both the finer organic particles in suspension and the colloidal matters that would be precipitated?

A. I understand these questions as relating entirely to Newark Bay?

Q. I am speaking about the sewage effluent guaranteed in
3472 the stipulation.

A. At Robbins Reef, under those circumstances?

Q. Yes.

A. Oh, I would like in that case—I thought we were discussing Newark Bay, and the cases are so different; the velocity of the current, the depth and so forth are so different that I am not sure whether I answered those questions correctly because I assumed we were still discussing the Newark Bay proposition.

Q. Let me put this question to you, General. Would that sewage, effluent differ if it were discharged in New York Bay from what it would be in Newark Bay?

A. No, sir.

Q. So that your answers would apply, as they did apply, to the sewage effluent itself, did they not?

A. Not necessarily, sir. I want to know exactly what the questions were.

The point is this, whether it is deposited, or not, in a shallow, flat place, without any current, scarcely, is a very different proposition from whether it will be deposited in water seventy-five feet deep and placed in a current of some rapidity and forty feet below the surface. The tendency is to raise up, and if it is in that condition the question of whether there is a deposit or not is very different *it if* is to fall

thirty feet before it is deposited, as an illustration, or whether it is only six inches.

Q. But the essential feature, that there would be deposit no matter where they were deposited, is correct, is it not?

A. As that question is put, I suppose it is, only it may be this, that it might be one-tenth of one per cent in one case and fifty per cent in the other. There is such a difference that the answer might be misunderstood.

Q. The only difference, as I understand, that is in your mind relative to the deposits in these respective locations at Robbins
3473 Reef and at Newark Bay depends on the velocity of the current and the shallowness of the body of water in one case and the depth of the body of water in the other case; these are the qualifying factors?

A. Those are the main—yes, sir.

Q. But the deposits, no matter where they are made, come from the sewage effluent and are about the same in amount; is that correct?

A. Oh, no, sir, no, sir, for instance—yes, but as a part of it, in the Atlantic Ocean where the discharge occurs this deposit is where it does no harm and in the other case it is deposited where it does injury. I was answering the questions as to where it was very shallow, that it will be deposited very quickly and do a great deal of harm. There is a difference, for instance, whether it is deposited in one hour or in a week or three weeks.

Q. I am not concerned so much with the injury from the deposit as with the fact of the deposit, that fact remains the same for both the locations, does it not, apart from the injury in one location?

A. I hardly think so, Doctor. Let me illustrate: Organic matter that can be deposited in half an hour will be deposited there but if it is going to remain in suspension for a week or a month it would be destroyed before that time comes and there is nothing to deposit, so I do not think that I could say that I agree to that.

Q. You are speaking now of the organic matters that would be deposited?

A. Yes, sir.

Q. That would not apply to the inorganic matter?

A. No, sir.

Q. Such as dyes and matters of that kind, particles of inorganic grit and matters of that kind?

3474 A. Yes, sir, absolutely insoluable matter—if it was insoluable matter. But even that may remain in suspension so long that it is carried out to sea before it falls, for all I know; if its specific gravity was small I could see how it could be carried out to sea before it was ever deposited.

Q. Then if I understand you right, General, the visible suspended particles would remain in suspension longer when discharged at Robbins Reef than they would in Newark Bay. Is that correct?

Mr. Riker: He has not said so, Doctor, he has not said anything about visible suspended particles so far. I object to the question on that ground.

The Commissioner: Note the objection of the counsel for the defendants.

Mr. Riker: If you mean to say assuming there are visible suspended particles that would be one thing, but he has not said there would be.

A. Of course they would because in one case—this is on the assumption that they deposited on the bottom eventually—they may have six inches or one foot to fall and in the other case they may have seventy feet—seventy-five feet I believe in the depth at that point—to fall, and of course they would remain in suspension longer at Robbins Reef.

Q. Your answer now relates to the sewage effluent stipulated for in complainant's exhibit No. 135.

A. Yes, sir.

Q. General, I do not know whether I understand you aright or not, I understood you to say that the English sewage was from one-third to one-half the strength of American sewage and I ask you if you did not mean it the other way, the reference to that?

A. The statement I make is quoted from the last edition, published last year, of the Encyclopedia Britannica on sewage
3475 and which statement I copied; it states that a million gallons of standard sewage—English sewage—contains two ton of suspended matter, one of organic and one of inorganic; I calculated that out and I can let you see the calculations, and I found that it meant one pound of suspended matter, half mineral and half the other, to about 1,860 pounds of water; that means, half a pound of inorganic matter to 1,860 of the other; as I have stated, I am not a sewage expert sir and I am answering at a disadvantage and am giving simply what I have been told—what I have read.

Redirect examination by Mr. Riker:

Q. You were asked in regard to visible suspended particles in the effluent provided for in this stipulation between the U. S. Government, the State of New Jersey and the Passaic Valley Sewerage Commission; I draw your attention to the fact that this stipulation provides there shall be no visible suspended particles; have you that in mind?

Dr. O'Sullivan: I object to that question. This is clearly a statement of counsel which he asks the witness to verify or contradict and I would rather he would put it in the form of a question instead of a statement.

The Commissioner: Note the objection of counsel for the complainant.

Q. I draw your attention to the fact that in this stipulation there is found this clause: "There will be absence in New York Bay of visible suspended particles coming from the Passaic Valley sewage"; had you that in mind when you testified that you were referring to the effluent from the Passaic Valley sewage?

A. Yes sir.

Q. Do you mean by that that in your judgment there will be visible suspended particles there?

Dr. O'Sullivan: I object, this is cross examination of his own witness.

3476 The Commissioner: Note the objection of the counsel for the complainant.

A. No, sir. My idea is, if there was any, and that I understood was the object of the question, that if there was any suspended matter, if it is a foot below the surface or an inch, or what not, it will stay longer before it is deposited.

Q. Assuming there were visible suspended particles, they would remain longer in the water of New York Bay than in the water of Newark Bay?

Dr. O'Sullivan: I object to that as not a question but it is a statement of counsel.

The Commissioner: Note the objection of the counsel for the complainant.

A. (Question not answered.)

Q. Had you intended to calculate the results of the sedimentation process which is described in this stipulation upon the inorganic matters in the sewage?

A. No, sir, I had not.

Q. Do you know how much of the organic matter will probably be removed by that process?

A. I do not, sir. I am simply assuming that there will be a very large amount, of the larger, heavier things, and that the sewage would not be as strong as the average American sewage; but I think I have based my answers on the American Sewage, supposing it was that strong.

Q. When you testified to the discharge of this particular effluent in Newark Bay, had you in your thought anything except the diluting power of the water in Newark Bay as compared with that of New York Bay?

A. I had also the question of the depth of the Bay; the difference is so very great in the two cases that the deposits will be in the Newark Bay almost instantly and the other will take some time.

3477 Q. And had you in mind anything except the matter as it concerned the control of the channels and the navigation of the Bay?

A. No sir.

Q. Do you know whether the increased standard of sewage per capita from thirty gallons, in England, to from one hundred and fifty to two hundred and fifty at other places does or does not involve an increase in organic matter in that sewage?

A. To answer that question I must state that the thirty gallons of water per person, in giving the standard sewage, is based upon domestic sewage, that part, the thirty gallons per person, and does not cover, as I understand, the question of manufactories and as to

what effect the manufactories would have upon it I have not the data and do not know anything about.

Q. So you do not know, then, do you, whether the largely increased estimate of, say, one hundred and fifty gallons per person does or does not involve an increase in actual organic contents?

A. It would not as far as the people are concerned, the domestic; but I assume that that large amount, that large estimate that has been made here, is based upon the need of the manufacturers, I assume that, because otherwise it would be unnecessary.

Q. Where the increase arises, do you think the organic matter would be increased?

A. It would be diminished, of course, in proportion.

Recross-examination by Dr. O'Sullivan:

Q. Do you regard soap as organic matter?

A. I should say yes, but how much is of the other I don't know, I am not a chemist, olive oil is certainly organic.

Q. General, the sewage effluent as stipulated for in complainants' exhibit 135 would occasion the deposits you have described if deposited in the Newark Bay, would it not?

A. I would have to state that, sir, with a qualification.

3478 If that sewage is of the strength of what is assumed for American sewage, the average strength of American Sewage, which I understand includes manufacturing, and so forth, in the proportion of one to the thousand of organic matter, that would be true. Whether it would or not, would require a sewage expert or a chemist—their opinion upon it; that of an engineer would be worthless on a question of that kind.

The further taking of testimony on the part of the defendants was adjourned to the call of the Commissioner.

3479 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker and Riker, Newark, N. J., Tuesday, February 11, 1913.

Before James D. Maher, Esquire, Commissioner.

Appearances:

Thomas Carmody, Esquire, Attorney General of the State of New York; William A. McQuaid, Esq., Deputy Attorney General; Dr. William J. O'Sullivan, Special Counsel, for the People of the State of New York, Complainants.

Edmund Wilson, Esq., Attorney General of the State of New Jersey; Robert H. McCarter, Esq., Of Counsel for the State of New Jersey; Adrian Riker, Esq., Of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

SAMUEL M. GRAY, a witness produced on behalf of the Defendants, being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you live?
A. Providence, Rhode Island.
3480 Q. What is your business or profession?
A. That of a civil and sanitary engineer.
Q. How long have you been engaged in that profession?
A. Since 1862.
Q. What has been your education for that profession, Mr. Gray?
A. At the age of about eighteen I prepared for Harvard. Ill health overtook me; I was obliged to give up attending. The- I took a trip abroad. On my return I entered directly into engineering work. I was, in the early stages of it, on railroad work and later on on water and sewerage, and for the last thirty-five or more years have been engaged actively in the construction and operation of water plants and sewerage works.
Q. Will you state some of the places and plants with which you have been connected in their operation or construction?
A. From 1884, I was City Engineer of Providence for some fourteen years, during which time I had charge of highways, water, sewers, public buildings, and then for a term of perhaps five years was also a member of the Board of Public Works which had charge of all the different works; in 1884 I was sent abroad by the City of Providence to study the various modes of sewage disposal in Europe,

visiting England, Scotland, Italy, Switzerland, Germany, Holland and some other places. On my return I designed a system for sewage disposal for the City of Providence. I was also appointed as one of the two to design sewerage disposal work for Toronto, Ontario; was appointed by the late President Harrison as one of three to design sewerage works and sewage disposal works for the District of Columbia; was appointd by the late Mayor of Philadelphia—his name goes from me at this moment—as one of three to design works for the purification of the water of the City of Philadelphia; was appointed by the later General Ludlow to visit Havana and design sewerage works and sewage disposal works for that city; designed and built sewerage works for Albuquerque, New Mexico; was
3481 appointed as one of two to remodel the sewerage works of Worcester, Massachusetts, and have been engaged in many like undertakings.

Q. Are you still practicing your profession, Mr. Gary?

A. Yes sir.

Q. Where are you located?

A. I am located in Providence, my office is there.

Q. Are you a chemist by profession?

A. No sir.

Q. A bacteriologist by profession?

A. No sir.

Q. Have you any special acquaintance with either of those branches of science?

A. I would not claim that I have, excepting, of course I have been more or less familiar with them, but I should not claim that I was either.

Q. In the practice of your profession as a sanitary engineer in connection with sewage disposal is it your practice to approach your problems from the point of view of a chemist or bacteriologist?

A. Yes sir, from all sides.

Q. Have you any especial familiarity, or what familiarity have you, with the waters of New York Bay?

A. My knowledge of them is simply what I have seen travelling back and forth over the Bay, and particularly on my way south and west and returning, and occasionally on excursions down the Bay. I have not examined them personally with direct reference to this case.

Q. Do you have any knowledge of the methods of sewage disposal being pursued by the City of New York?

A. I know of no methods of disposal in use there, excepting to discharge it crude into New York Bay, Hudson River, and so forth.

Q. Have you made any study in detail in any way of the
3482 results of that discharge on the waters of the Bay?

A. No sir, except to read the late report of the New York Sewerage Commission appointed to advise as to what may be done in the future.

Q. In your passing up and down from your home city to the various points you have visited, over the waters of New York Bay, have you made any observations of any kind as to the condition of

the waters of New York Bay so far as they are affected by sewage discharged from New York?

A. I have simply made casual observations by sight and by seeing if there were odors, as I have often been somewhat surprised that the vast quantity of sewage emptied in from New York has not produced worse conditions. That is the extent of my observation.

Q. As to the conditions which you have observed casually, do you consider them or do you not consider them particularly objectionable at the present time?

A. I would like to answer that and explain the meaning of my answer.

Q. Yes.

A. I do not, in one sense, not that they are unlike many other places. They are not intolerable. I must say however, that I believe in the principle of disposing of sewage in a way as not to cause a nuisance, and these different ways are very different depending on conditions of each place. But the time is approaching when we should, and I believe it is proper we should, pay just attention to the disposal of our sewage so as not to offend our neighbor or ourselves.

Q. Have you made any special study or observation of the condition in the Passaic Valley?

A. Yes. In 1902 and 1903, I think it was, I was employed by the City of Paterson before the different cities had joined in the trunk sewer project, to see if that city could dispose of its sewage properly without joining in the trunk sewer. I made surveys estimates and a report upon it then. I also at that time examined
3483 the Passaic River up and down, more or less. Do you care to have me say anything further about that?

Q. I would like to ask you what conclusion you reached in connection with the particular problem in the City of Paterson in reference to a separate disposal plant.

A. I reached the conclusion that they could thoroughly dispose of their sewage without joining the trunk sewer, but that it would be very unwise for them to undertake to do it, and advised them to join the trunk sewer movement.

Q. In that study for the City of Paterson did you look into and consider the plan of the Passaic Valley Sewerage Commissioners?

A. Yes sir, as far as it was then developed.

Q. At that time did you find that there was any especial purification scheme involved in the Passaic Valley plan?

A. I forget at this moment whether in 1902 and 1903 the plans were fully developed, although I think they were developed then, but since then I have examined the proposition more carefully.

Q. How lately have you made an examination of the plan of the Passaic Valley Sewerage Commissioners?

A. During the last two years I have given considerable attention to it.

Q. I show you Complainants' exhibit Number 135 in this case being a stipulation in the Supreme Court of the United States in the case in which you are testifying, entered into in behalf of the

2385

State of New Jersey and the Passaic Valley Sewerage Commissioners with the United States Government, and ask you whether that was part of the plan as you considered it during your last examination of the plan of the Passaic Valley Sewerage Commissioners?

A. This precise paper I have not seen before.

Q. Just look it over and see whether it is in substance the same as the one that you examined?

A. (After an examination of the document.) Yes, I should say that was precisely it.

3484 Q. Taking the plan, as you have examined it, of the Passaic Valley Sewerage Commissioners, including in it for your consideration this stipulation, what, in your judgment from your experience in similar works, will be the result of the discharge of the effluent, produced in the way specified in this stipulation, upon the waters of Upper New York Bay?

A. It seems to me there will be no bad results. I see no difficulties unsurmountable or unreasonable in the requirements of this contract, and see no reason why they cannot be carried out, and if carried out fully, believe that they will result in the conditions which this contract demands should exist.

Q. If the work and processes of partial purification specified in this stipulation are put into effect by the Passaic Valley Sewerage Commissioners, in your opinion will the results that are guaranteed by the State of New Jersey and the Passaic Valley Sewerage Commissioners in this stipulation be attained?

A. I think they will.

Q. Assuming that the purification devices are constructed and the processes are carried out, described, in this stipulation, what in your judgment will be the effect of the effluent discharged from that plant into New York Bay at Robbins Reef, so far as the waters of the Upper Bay are concerned, as compared with the effect of the discharge of the waters of Newark Bay, in its present condition, into Upper New York Bay, through the Kill von Kull?

A. It seems to me that there will be an improvement in this, that the waters of the Bay will not be as badly polluted from sewage coming from the Passaic Valley as they now are.

Q. In giving that answer, what do you assume as to the percentage of the waters of Newark Bay which find their way into the Upper Bay through the Kill von Kull?

A. I have not gone into that.

Q. In considering this problem of the effect of the discharge of the effluent as likely to be produced by these devices and

3485 processes in the water of the Upper Bay, on what do you reach your conclusion; is it on chemical or bacteriological considerations or dilution?

A. It is a consideration such as I am able to give from my contact with the question of chemical action and biological, coupled with my general experience in such cases where sewage is diluted much less than it will be in the Bay, taking the figures of tidal flow and quantity of sewage that have been stated in the evidence given.

Q. If the City of New York should apply to its sewage which is

now discharged crude into New York Bay the same processes which are provided in the stipulation, Exhibit 135, what in your opinion will be the general result upon the waters of the Upper Bay?

A. They certainly will be improved from what they are now; that must inevitably be the result of keeping out a large amount of floating matter; which must be kept out and which now enters, and the keeping back of a great deal of silt, which must find its way into New York Bay, thus causing less pollution to go in than now does.

Q. Would the result of that process, or those processes, if applied by the City of New York, make the waters of the Upper Bay capable of taking care of and disposing of a much larger pollution than there is now discharged into it?

A. I think so.

Q. Are there other devices and processes which might be applied to the Passaic Valley Sewage, to the end of producing an effluent which will comply with the stipulation, in case the methods described in the stipulation should turn out to be insufficient for that purpose?

A. You mean in connection with, or in addition to, the present methods?

Q. In addition to.

3486 A. Yes sir, I think there is no question about that.

Cross-examination by Dr. O'Sullivan:

Q. I understand you did not take an educational degree in Harvard?

A. No sir.

Q. Or any other institution?

A. No sir.

Q. And that you did not graduate as a Civil Engineer?

A. No sir.

Q. And that you did not take any degrees in either chemistry or bacteriology?

A. No sir.

Q. You have made no special study of biology?

A. No sir.

Q. Did I understand you to say that you designed the water works for Philadelphia?

A. No sir; I did not mean to be so understood. I was appointed one of three by the late Mayor Ashbridge to design works for the purification of the waters both of the Schuylkill and the Delaware.

Q. Did you design them or did you simply report on them?

A. We designed the works, the purification works, not all in detail, but in general, and quite sufficient. We recommended the slow sand filtration; we chose the points at which these works should be built; we visited each pumping station, each reservoir, and recommended the use of certain reservoirs which are now storage reservoirs, as covered reservoirs, to retain the water.

Q. Under whom did you first take up any work in engineering?

A. T. Willis Pratt of Boston; he was the chief engineer of the

then Boston, Hartford and Erie; that was my first experience then, as rod man.

3487 Q. When did you first do any work in constructing sewers?

A. I should say in the latter part of the seventies or the first part of the eighties; I do not just remember.

Q. Was it before or after you visited Europe?

A. It was before.

Q. Where did you design those sewers for?

A. I designed them for Willimantic, Connecticut—I cannot be sure that all this was before that time, the dates I cannot recollect—and for Providence, Rhode Island.

Q. That was after 1884, was it not?

A. That was before. Part of it was after; part of it was before.

Q. And that dealt chiefly with the construction of the sewers themselves, did it not?

A. No sir. It did deal with that absolutely, but it also dealt very decidedly with the disposal of sewage of the City of Providence, which was really the main part of the work.

Q. In 1884 were there sewage disposal works designed for Providence, Rhode Island?

A. I was designing them then myself.

Q. Were they ever installed?

A. Yes sir; they have been built and put in operation.

Q. When were they installed?

A. I should say three or four years after I designed them; it might have been more years, but for many years now, they have been in operation.

Q. How did these disposal works contemplate purifying the sewage?

A. By chemical precipitation; by building tanks, admitting the sewage to those tanks and putting in a certain amount of sulphate of alumina or lime and precipitating the solids in suspension and perhaps small parts of the impurities in solution, the sludge settling to the bottom. The effluent was then drawn off, the sludge

3488 passed through presses that pressed out the water and was made into cakes which could be handled; these were first disposed of as a fertilizer, but did not seem to possess value enough for the farmers to pay much for them and that is now discharged down the bay in scows.

Q. Where did you get the idea of chemical precipitation which you applied?

A. In Europe.

Q. In England?

A. Yes sir.

Q. In London?

A. No sir. In many places in Europe, not particularly in London, they were then, I think, not practicing it there.

Q. Are you now in favor of chemical precipitation as a method of sewage disposal?

A. I would advise different methods for different places. That

is perhaps illustrated in this way: For a man with a broken arm we would use splints, but for a man with consumption, we would not put them on. The same variety of treatment must apply to the disposal of sewage.

Q. Do you advocate chemical precipitation now?

A. No sir.

Q. Were those sewage disposal works in Providence, Rhode Island after you had severed your connection with the City authorities?

A. They were built after that, and built according to the plans as designed.

Q. What did you do relative to the Washington sewerage system, the present sewerage system?

A. We designed the main trunk sewers, also the sewer down the Potomac; recommended discharge of the sewage at first in the crude state and making sure and ascertaining that there were areas on which the sewage could be treated in one way on another.

3489 Q. When did you design those sewers for Washington?

A. The date I cannot give you, excepting that it was during the late President Harrison's time.

Q. Do you know whether that sewerage system is still in use in Washington?

A. As far as I know, generally, they undoubtedly made some digressions from it.

Q. Have they in any way modified the system in Washington that you installed?

A. I cannot say for I have not examined it.

Q. Have you read Mr. Phillip's testimony in this case?

A. I do not remember. I have read considerable of the testimony of different witnesses, but I cannot say at this moment whether I read Mr. Phillips' or not.

Q. In the system which you installed in Washington during the regime of President Harrison, were sewage disposal works any part of the system?

A. They were in anticipation, but for immediate disposal, not.

Q. Do you know whether they were ever adopted, any sewage disposal works in connection with the system you installed in Washington?

A. I have no information of any.

Q. As far as you know, there are no sewage disposal works there now?

A. I cannot say that there are, no sir.

Q. What was the grade of these sewers you designed for Washington, the average grade?

A. I do not recollect, sir, at all. Those things, I do not carry them in my mind.

Q. You got a rapid discharge, did you not?

A. Undobutedly in some of them, and in some of them probably not; I cannot say at all about that.

490 Q. Did you make any calculation in Washington as to the age of the sewage by the time it reached the Potomac?

A. Yes sir, we did, but what that age was I cannot say.

Q. Would you say it was fresh or stale sewage by the time it reached the Potomac, under the system which you installed?

A. That term would have to be qualified a little; I should say it was on an average.

Q. Between fresh and stale?

A. Why, yes. I would not call it fresh and I would not call it stale.

Q. What distinction do you recognize between those terms as applied to sewage—fresh and stale?

A. Sewage which has become septicised may be considered stale; sewage which has been retained long enough to become stale is stale; sewage which reaches the disposal works before it becomes stale is fresh. That is about the only explanation I can give.

Q. We were discussing condition. What effects produce these conditions as between fresh and stale sewage?

A. There are two—there may be more, lengths of time after it is made before it reaches the disposal plant, and the ingredients of the sewage.

Q. Does time enter into the factors which draw the distinction?

A. Oh yes.

Q. Do you, in your own mind, make any distinction between stale and septic sewage?

A. There could be, but that is a very close point, the lines come very near together. Of course, sewage which is septicised has passed through the stages of being foul.

Q. I am asking you how you distinguish, or whether you do distinguish or not, the terms stale and fresh, as applied to sewage, and if so, what the distinction or differentiation con-

3491 sists of?

A. I should say that stale sewage was the first step, the early action, of septicisation.

Q. What would you look for in sewage to determine in your mind whether it was stale or septic or fresh?

A. In fresh sewage I should look for the odors; I should look for signs of floating matter, paper, corks and excrements particularly, and those things. In stale sewage I should look for those more strong odors; putrified sewage to a certain extent.

Q. How long does it take sewage ordinarily to leave the fresh stage and become stale, under the distinctions you have now made?

A. Oh, I could not say, sir. That is one of the infinitestimal questions.

Q. Can you give me an approximation?

A. Oh, I think, in fact, I know, that in a week's time many of the sewages would become stale.

Q. And during that week sewage is usually fresh?

A. Not always, it may become stale earlier than in seven days.

Q. How early, in your experience, has sewage become stale, measuring it in time?

A. My general recollection and opinion of that would be in two or three days, possibly.

Q. And in your experience sewage has retained its freshness as a general proposition, for two or three days?

A. I have seen sewage retain its freshness, that is, not become stale, what I would call stale, for two days.

Q. Have you ever known sewage to become stale in three hours?

A. I don't know that I have.

Q. Will you say it is improbable or impossible?

A. In answer to your first question, whether I recollect
3492 it, I should say no, I do not; and in answer to the second one, I should think, on general terms, general cases, it was improbable.

Q. What would be the earliest time in which you would expect fresh sewage to leave that condition and become stale?

A. As I have said, the term admits of qualification, but taking it as one would naturally understand it, I would not look for its being what I would call stale inside of a day.

Q. What occasions staleness in fresh sewage?

A. The decomposition of the matters of which it is composed.

Q. What occasions these decomposition changes?

A. Chemical action, biological.

Q. Which is it?

A. Both.

Q. Through what biological agencies is sewage rendered stale?

A. The first, the very first, is the action of bacteria on it, which, as it proceeds, purifies it.

Q. How do they operate in purifying the sewage?

A. I am not a bacteriologist; I should not care to enter into that in detail, but generally by the oxidizing, carrying oxygen to it.

Q. As long as there is sufficient oxygen for these bacteria to operate with will sewage become stale, according to the way you distinguish stale from fresh sewage?

A. I cannot say.

Q. Do you distinguish the functional activities of groups of bacteria like aerobic and anaerobic?

A. Yes, the anaerobic acting in the dark, the aerobic operating in light and air.

Q. That is as you understand them?

A. That is as I understand them.

Q. What are the products of bacterial action, as you understand it, when they render fresh sewage stale or septic?

3493 A. I do not understand your question.

Q. (Last question read to witness.)

A. They, as I understand it, break up sewage from its raw state, enabling the aerobic bacteria to operate upon it.

Q. In breaking up the organic matter in sewage and giving rise to the distinctive odors that enable you to call it stale, I ask you what odors they are; what are they due to; what is the product which occasions those odors?

A. The impurities in the sewage.

Q. Is that the best answer you can make?

A. I think it is.

Q. Is hydrogen sulphide ever evolved from these bacterial actions?

A. Yes sir.

Q. Would that gas enable you to distinguish whether or not sewage had septicised?

A. I should expect to find that gas and smell it during the process of septicising.

Q. You say you have been along the Passaic River. I ask you if you have ever smelled that gas as a distintive odor along the Passaic River?

A. Yes sir.

Q. Did you have any difficulty in locating it?

A. I do not know what you precisely mean. When I was along the brink at certain points I smelled it.

Q. Very distinctive, was it?

A. In some cases it was.

Q. Can you detect by odor the gas methane?

A. No sir.

Q. Can you detect carbon dioxide, that gas?

A. I would not say that I could place it.

Q. Have I now mentioned gases that are the product of septic decomposition?

3494 A. You have some of them. I cannot say that all you have mentioned are not products of it.

Q. Would you describe the present condition of the Passaic River as a condition of septicisation?

A. To a greater or less extent, yes.

Q. Is it but little more today than an elongated septic tank?

A. I should say it was more than that. I should not call it quite as bad as that.

Q. Have you studied the trade wastes that are discharged into the Passaic River at present?

A. Yes.

Q. How many different kinds of factories discharge organic trade wastes into the Passaic River at present?

A. As I have stated, my examination of that river was in 1902 and 1903. Later than that, I cannot find an answer to your question. At that time there were wool washings and dye stuffs, and as I remember it, some tanneries, and there were wastes from other manufacturies into the river.

Q. What organic matter is in the trade wastes from silk factories or mills?

A. I cannot say except that they give it a color oftentimes very different from what it would be if those wastes were not in it.

Q. Do you know what volume the trade wastes of the Paterson silk works, for instance, would equal?

A. I do not.

Q. What other trade wastes are discharged beside those from silk works and tanneries?

A. At that time there were wool washings.

Q. Are those rich in organic matter?

A. Yes.

Q. And highly putrescible?

3495 A. Generally.

Q. What other organic trade wastes beside those we have mentioned can you recall?

A. Applying to this river?

Q. Yes.

A. I have an impression there were some breweries, but will not be sure that they apply to Paterson.

Q. Taking the full length of the river, name some of the factories or mills that discharge organic trade wastes into the Passaic River now?

A. I cannot tell you, sir, as to now.

Q. They discharge directly into the river now?

A. I cannot say as to now. They did at Paterson at that time.

Q. Whatever sewage is discharged now into the river is discharged near the location of the creation of the organic trade wastes?

A. I cannot say as to that; I suppose it is.

Q. And that sewage you have described as being in a condition in the river that has produced something but little better than a septic tank?

A. I do not want to be understood just as your statement puts it. I do not mean to say that it is only a little better. I mean to say that I would not class it as septic sewage or as a septic tank.

Q. I understood you to say that it evolved the gases that are peculiar to septicisation and that you detected them.

A. I did, some of them.

Q. Then would you describe the sewage as septic when it gives off the products of septicisation?

A. Not completely necessary.

Q. What would it lack to make it complete?

A. Time.

3496 Q. What would time accord to it that it lacks?

A. It would break up more thoroughly rendering it more ready for the aerobic bacteria to act upon and oxygenize it.

Q. Would not the aerobic bacteria have to be working to evolve sulphurated hydrogen?

A. Yes sir, I so understand it.

Q. When you have that condition you have a condition of septicisation, have you not?

A. It is being septicised.

Q. Do you think sewage would be improved if carried a long distance in a trunk sewer and detained in disposal works for some time and given opportunities for sedimentation and then discharged through a long tunnel?

A. I understand, and if I am wrong, I would like to be corrected, that you apply that question in connection with the method in which it is proposed to treat it. If so, there are some conditions left out; the screens, the silt chambers, the baffle-boards and other processes.

Q. These all take sometime, do they not?

A. Yes.

Q. I say, adding that time to this condition of the sewage you think it must add to its septicisation?

A. Why, I think when the sewage was discharged it certainly would be improved, at the time it was discharged, taking into consideration the time that these various processes require.

Q. After septic action once sets in, is it continuous under the conditions that you have described?

A. Yes, generally, if allowed to be continued.

Q. So that that sewage would reach the outfall at Robbins Reef in a septic condition, would it not?

A. More or less so.

Q. Does septic sewage consume oxygen more rapidly than fresh sewage does.

3497 A. I cannot tell you.

Q. Do you know if the processes by which septic sewage consumes oxygen are different from the processes by which fresh sewage consumes oxygen?

A. Not being a bacteriologist, I cannot tell you.

Q. Will you say there is not a chemical question involved in the inquiry I have just put to you?

A. No sir, I will not say there is not.

Q. Which of these trade wastes are richest in collodial matters?

A. I should expect that the wastes from the tanneries, and the wool washings might be.

Q. Is there any provision in Complainant's Exhibit 135 for removing these colloidal matters?

A. It seems to me there are, that there is a certain result to be obtained.

Q. Can you remove colloidal matters by screening?

A. Not according to the screening that is there described.

Q. With coarse screening?

A. Well, both the coarse and the fine.

Q. Would you call four tenths of an inch mesh a fine screen?

A. I would.

Q. Is that your idea of a fine screen, Mr. Gray?

Mr. Riker: He did not say that. He said he would call it a fine screen.

A. It would be a fine screen to screen water, but is depends on the use of the thing as to how it may be termed.

Q. Are there finer screens in sewage disposal works?

A. There have been.

Q. Are they now in use, to your knowledge?

A. I cannot say. I have known burlaps to be used.

Q. That is a very fine mesh compared with this four tenths of an inch mesh, is it not?

3498 A. When you take into consideration all the fiberous matters that extend all through it, it is.

Q. Do you believe that any screening, no matter how fine will remove colloidal matters in sewage or from sewage.

A. I would not want to say that it could not be removed by a method of screening.

Q. How do you distinguish between colloidal matters and matters in solution, organic matters in solution?

A. I cannot tell you, sir.

Q. Do you mean to say there isn't any distinction?

A. I cannot tell you.

Q. Then how do you know colloidal matters can be removed by screening, if they are undistinguishable from organic matters in solution?

Mr. Riker: The question is objected to because the witness has not said they are indistinguishable.

The Commissioner: Sustains the objection of counsel for the defendants.

A. I cannot tell you, I don't know.

Q. Is there any provision in Complainant's exhibit 135 for removing organic matter in solution?

A. Just as you put the question, I should say not.

Q. Is any provision there for removing pathogenic germs or disease bearing germs from the effluent, prior to its discharge, in complainant's exhibit 135?

A. More or less of them, yes.

Q. How?

A. By the removing of the silts, which the coarser screens and finer screens and the sedimentation of the sewage will produce.

Q. By screening and sedimentation you can remove disease bearing germs, can you.

A. There will be more or less, yes sir.

Q. Removed?

3469 A. Yes sir.

Q. What percentage of them would you remove that way?

A. I cannot tell you.

Q. Would you remove half of that?

A. I cannot say.

Q. A quarter of that?

A. I would not wish to state.

Q. Would it not be as a matter of fact an infinitesimal amount that you would remove by sedimentation and screening?

A. I should not look at it in that way.

Q. Will you give me some approximation as to the percentage of just what you would remove?

A. I cannot in this case.

Q. Does septic sewage or fresh sewage contain more organic matter in solution?

A. I should expect that the septic sewage would contain more.

Q. And is the organic matter in solution in septic sewage more putrescible than the organic matter in fresh sewage—the organic matter in solution?

A. I think it is.

Q. And will more readily consume oxygen with which it comes in contact?

A. I should say it would more quickly do so.

Q. In speaking about those fine screens, do you know how fine the mesh is in the screens in the sewage disposal works at Dresden?

A. No sir.

Q. Do you know how fine the screens are in the sewage disposal works at Cologne?

A. No sir.

Q. Did I understand you to say that your knowledge of this Passaic Valley sewerage project was confined to your examination in 1902.

3500 A. I did not mean to be so understood.

Q. What part of your knowledge have you acquired since?

A. Since that time I have had the contract which has been referred to between the United States and the State of New Jersey, I have also *have* seen the plans as proposed to be carried out and have read more or less of the testimony given in regard to it, during the last two or possible three months.

Q. During the last two or three months your information and knowledge have been confined you say to this stipulation between the Federal Government and the State of New Jersey, a study of that?

Mr. Riker: The question is objected to because the witness did not say so.

The Commissioner: Note the objection of counsel for the defendants.

A. No sir, that is not my answer.

Q. What subject matter besides complainants' exhibit 135 have you had under consideration during the past two months?

A. As I have stated, more or less of the testimony given in this case, and the plans as shown me by the Chief Engineer, Mr. Brown, in his office, of what is proposed.

Q. How recently did Mr. Brown show you those plans?

A. I should not think it was a month ago.

Q. Was it a week ago?

A. Yes sir.

Q. How often have you looked at those plans?

A. I have looked at them once, through.

Q. How many volumes were there to the plans?

A. I could not tell you, I do not remember.

Q. Was there more than one?

A. I could not say, that did not attach itself to my memory.

Q. You looked at them over a week ago?

3501 A. More than a week ago.

Q. More than two weeks ago?

A. Yes sir.

Q. More than three weeks ago?

A. I would not say it was and I could not say it was not.

Q. You do not know how many volumes there were of those plans?

A. That I did not take in, we looked them over sheet after sheet.
Q. Did Mr. Brown show you more than one volume?
A. I cannot tell you.
Q. Do you know how many provisions in those plans have been made for the escape of sewage on certain occasions into the Passaic River and into Newark Bay?

Mr. Riker: The question is objected to on the ground that it is not cross examination and is immaterial and irrelevant to this issue.
The Commissioner: Note the objection of counsel for the defendants.

A. No sir.
Q. How recently have you examined the Passaic River?
A. You mean its full length I presume, or generally?
Q. From Paterson down or any substantial part of the river; state how much.
A. Not since 1903.
Q. You do not know whether it is worse now or better than it was in 1903?
A. Not from actual examination.
Q. Do you know how large the calibre of the Trunk Sewer is?
A. I have known but I cannot tell you now.
Q. Do you know whether or not the calibre has been decreased or diminished within recent times, that is since 1902?
A. I cannot say, I do not know.
Q. What plans of the Passaic Valley Sewerage Commis-
3502 sioners' project did you see, what date was on them?
A. I do not know the date, I did not observe the date.
Q. Do the plans which were submitted to you by Mr. Brown differ in any material fact from the scheme or plans described in complainants' exhibit No. 135?
A. In a general way I think not.
Q. Do you know when complainants' exhibit No. 135, which is a stipulation between the two governments in Washington and in Trenton, was executed?
A. No sir.
Q. Refresh your mind on that Mr. Gray.

Mr. Riker: He cannot refresh his mind; he had no part in it and I object to the question; this witness had no part in that stipulation and the stipulation itself shows when it was executed.
The Commissioner: Note the objection of counsel for the defendants.

Q. What do you understand to be the sewage disposal scheme that is now contemplated by the Passaic Valley Sewerage Commissioners?
A. To first screen the sewage, taking out the large floating matter; to provide grit chambers for the deposit of the grit; to provide screens, final screens and also sedimentation basins and pumping works and an outfall sewer or tunnel or whatever you may term it; the effluent to be discharged into forty feet of water near Robbins

Reef, through openings, as I judge, of about twelve inches; I forget just how many at this minute but a great many; also in the sedimentation plant baffle boards to catch any further floating matter, if there be any.

Q. Those are usually designed to retain grease, are they not?

A. Anything that is floating; they will retain grease or
3503 anything else.

Q. What is your opinion as to the efficiency of these contemplated multiple outlets?

A. Efficiency in what regard?

Q. As to dispersion?

A. I think they will be efficient.

Q. On what do you base that opinion?

A. On common sense.

Q. Have you ever had any experience with multiple outlets?

A. Not exactly like these, but similar.

Q. Where?

A. In discharging sewage into various streams in various places.

Q. Through multiple outlets?

A. Yes sir.

Q. Where?

A. In our own city, in Providence.

Q. You have multiple outlets?

A. I was going to explain what I mean by that. In our own city of Providence the sewage is discharged at various points through various sewers, each being an outlet, the whole of them constituting multiple outlets.

Q. They have the same condition on Manhattan Island, according to your knowledge now, have they not?

A. I cannot tell you.

Q. Do they discharge through one sewer or a number of sewers?

A. I do not know.

Q. By multiple outlets you understand a number of separate sewer outlets?

A. No sir, not in this case I do not.

3504 Q. Have you not described such a condition in Providence as multiple outlets?

A. In answer to your question whether I knew of any other multiple outlets, I did mention Providence, but those multiple outlets are not comparable with these multiple outlets; I do know however that the discharge of crude sewage into one place produces a different result from distributing it up and down a body of water, whether it be to one or more sewers or not and the same result that is obtained in that case in my judgment would be obtained in this, but to a far more perfect degree.

Q. Did you not state a little earlier in your examination the fact that sewage in Providence went to disposal works and was not discharged through the trunk sewers or through these sewers you have described?

A. I did, applying to the present.

Q. Then this multiple condition in Providence related to a previous condition?

A. Yes sir.

Q. And it is the ordinary mode of discharging sewage along the Passaic Valley now, through separate sewers; you call that a multiple discharge?

A. That may be classed as such; I do not call it a multiple discharge, as applied to this contract at all.

Q. My original question was whether you have had any experience with multiple outlets such as described in the plans that are now adopted by the Passaic Valley Sewerage Commissioners?

A. I beg your pardon; I failed to hear you say "such as are now", I failed to hear you connect those multiple outlets with this contract.

Q. Then what is your answer to it now?

A. No sir.

Q. Do you know of any such multiple outlet system in
3505 the world as is provided by the Passaic Valley Sewerage Commissioners' plans?

A. No sir.

Q. You have described the contemplated sewage disposal treatment work on the Newark Meadows, do you believe this can be operated efficiently without giving rise to any local *m*uisance or offense?

Mr. Riker: The question is objected to as irrelevant and immaterial and impertinent.

The Commissioner: Note the objection of counsel for defendants.

A. I think they can.

Q. Were the disposal works that you designed for Toronto ever installed that you know of?

A. I understand they were, I have been told.

Q. Are you quite sure that they were?

A. No sir.

Q. How long ago was that?

A. I cannot tell you but it was many years ago.

Q. You mentioned something about the sewage of New York City and that it was all discharged crude; Mr. Gray do you know whether there are any sewage disposal plants in connection with New York City?

A. No sir.

Q. Have you kept up your interest in Toronto and its sewage disposal system at all?

A. No sir.

Q. Are you aware of the fact that Mr. John D. Watson of England was called upon to design sewage disposal works there that are now in use?

A. Yes sir.

Q. Then you do know that Mr. Watson's design was accepted and is in use?

3506 A. But that was not your question; you asked me if I kept up my interest; I know some things I am not interested in; I know he was over here but I had no interest in that.

Q. Do you know whether or not he designed the works that are now in use in Toronto for sewage disposal?

A. I do not, no.

Q. Do you know of any sewage disposal plants that are used by New York City and where they are located?

A. I have already said that I do not.

Q. How old would you say Manhattan Island sewage was when discharged into either the Hudson or the East River?

A. I do not know.

Q. You would regard it as very fresh, would you not?

A. I think I misunderstood your question.

Q. (Previous question read as follows: "How old would you say Manhattan Island sewage was when discharged into either the Hudson or the East River?")

A. I don't know, sir.

Q. Would you say it was more than half an hour old?

A. I would not say.

Q. Does not the age of the sewage make a great deal of difference in considering the question of dilution?

A. In some respects it does.

Q. Do you need a greater measure of dilution for fresh or for septic sewage?

A. I should, my ownself, not speaking from scientific standards, but on my own judgment, wish for a greater dilution of fresh sewage.

Q. Is that your best judgment?

A. That is my best judgment.

Q. You mentioned something about the capacity of New York Bay for the assimilation or digestion of sewage; what factors would you take into consideration in measuring the digestive capacity
3507 of any body of water, to digest sewage?

A. I do not think that I did measure the capacity, as stated in your question.

Q. I understood you to say that you took in the biological and chemical features of dilution, in answering questions to Mr. Riker?

A. Yes, sir.

Q. And those were factors you were considering with the view of the digestion of sewage that would be discharged into the upper bay, were they not?

Mr. Riker: The question is objected to on the ground that neither in the direct examination nor elsewhere did this witness testify to the digestive capacity of the waters of New York Bay.

The Commissioner: Note the objection of the counsel for defendants.

A. Yes, sir.

Q. What do you mean by dilution with regard to sewage discharge?

A. The relative quantity of water into which sewage is discharged as compared with the quantity of sewage discharged into it.

Q. In discussing the question of dilution do you have in contem-

plation the question of assimilation by that body of water of the sewage discharged into it?

A. I do not get the meaning of your question.

Q. (Last question read.)

A. Yes, sir.

Q. So that when you are discussing questions of pollution, you have in mind the digestive capacity of the waters, based upon that dilution?

A. It may be put so, yes, sir.

3508 Q. The character of the water into which you discharge sewage you have to consider before you can discuss the question of dilution?

A. That should be considered.

Q. Taking up the question of the character of the water in the upper bay what would you say it was?

A. You will have to make that rather more definite; what would I say what was?

Q. What was the character, the condition of the water? However, I will withdraw that question.

In discussing the condition of water, what factors in that water will incline you to discuss later its powers of assimilation?

Mr. Riker: The question is objected to as so obscure as not to be pertinent to this inquiry.

The Commissioner: Note the objection of counsel for the defendants.

A. As I understand it, or, more probably, as I do not understand it, I cannot answer it.

Q. You do not understand the question?

A. No, sir.

Q. Does it make any difference whether water is low in its oxygen contents or high in its oxygen contents?

A. Make any difference in what?

Q. In relation to the sewage that you would contemplate adding, or discharging into it.

A. Yes, sir.

Q. What is the oxygen contents of New York Upper Bay?

A. I do not know, sir.

Q. Will that be a necessary factor to take into consideration before you add sewage to it in great volumes?

A. If you were going into it to a very refined point, yes.

3509 Q. Does it make any difference in your consideration whether water is already heavily polluted or not before you add an increased volume of sewage and expect it to dilute that increased volume of sewage?

A. Yes, sir.

Q. What percentage of the water that comes into New York Upper Bay on the flood has already been in New York Upper Bay, been heavily polluted, and gone out on the ebb?

A. I cannot tell you.

Q. Is not that a necessary factor for you to take into consideration?

A. If you are going into it in fine figure, it would be.

Q. What is the tidal prism of New York Upper Bay?

A. I do not remember.

Q. Have you given any study at all to the length of time it takes for sewage discharged into New York Bay to leave the upper bay?

A. I do not know that.

Q. Do you know how deep these deposits of sludge are on the bottom of New York Upper Bay?

A. No, sir.

Q. Do you know how low the oxygen contents is in New York Upper Bay?

A. I have seen statements of it but I do not remember.

Q. Referring to the multiple outlets, what would you expect the sewage to do immediately on its discharge from those multiple outlets?

A. To mingle with the water into which it is discharged.

Q. Is sewage lighter or heavier than salt or brackish water?

A. Generally, in the main, it is lighter.

Q. What is the salinity at Province where the effluents are discharged, what is the salinity of the water?

3510 A. I cannot tell it in figures, but salt.

Q. Quite salt?

A. Yes, sir.

Q. Is there any difference as to whether you discharge sewage into fresh or salt waters with respect — what becomes immediately of the sewage?

A. I should expect a quicker sedimentation in salt water.

Q. As a matter of fact does not salt water act as a precipitant of sewage solids?

A. To a limited extent it does.

Q. To what extent does it?

A. I cannot tell you.

Q. What would you say?

A. I do not know, I cannot state.

Q. What is the salinity of New York Upper Bay?

A. I do not know.

Q. Will the sewage discharged at these multiple outlets rise vertically until it reaches the surface of the water of the Upper Bay?

A. I do not expect it will.

Q. Why?

A. I expect the current will carry it laterally, more or less.

Q. How would it be on slack waters?

A. I should expect the same, possibly to a less extent.

Q. Do you know of the currents in New York Bay?

A. I do not know of them.

Q. What do you know of the phenomena of the underrun?

A. I do not know.

Q. Is it not a uniform experience with sewage disposal systems

that sewage invariably rises from the outfall to the surface of salt water?

3511 A. I think you may call it uniform.

Q. You have read the stipulation, as set forth in complainants' exhibit No. 135, carefully, have you not?

A. The one that was handed to me?

Q. Yes.

A. Yes sir.

Q. And you have studied the character of the effluent stipulated for?

A. Yes, in that I have carefully read the stipulation.

Q. What objection would you have to discharging the effluent such as that which is provided for in complainants' exhibit No. 135, into Newark Bay?

A. Nothing.

Q. You do not see any possible reason why it should not be discharged into Newark Bay, do you?

A. Yes sir, but not in accordance with this stipulation.

Q. I am confining myself to the stipulation, what it stipulates for.

A. That is to be discharged into forty feet of water; you could not do it in Newark Bay.

Q. But I am asking about the effluent; if you will turn to the six provisions for the effluent, which it is to live up to; let me direct your *opinion* specifically to what is in my mind:—Directing your attention to page 3 of complainants' exhibit No. 135 I ask you if an effluent as good as it is therein stipulated for, if it would occasion any injury or nuisance if discharged into Newark Bay?

Mr. Riker: Objected to on the ground that the stipulation is for an effluent which will produce certain conditions in New York Bay and not for an effluent described generally, as a specific thing. The stipulation is confined to New York Bay and I therefore object to the question on the ground that it is irrelevant, immaterial and impertinent.

•3512 The Commissioner: Note the objection of counsel for the defendants.

A. I want to answer that question a little more than yes or no.

Q. As fully as you please, we are trying to get the whole facts.

A. The question asked me to express an opinion on only one-half the conditions; only one-half of the conditions, or only a part of them at any rate have been mentioned in the question. This effluent is to be discharged into deep water under different conditions than Newark Bay contains.

Q. Let us clear up that point. Will the effluent stipulated for in complainants' exhibit No. 135 differ in any particular, whether it is discharged into Newark Bay or into New York Bay?

Mr. Riker: The question is objected to on the ground that the stipulation is separate as to the processes and methods of the production and as to the results guaranteed in New York Bay and therefore the question should be made more specific, and divided. If the part of the stipulation referred to is the effluent produced by the

process, that is one thing; if the part of the stipulation referred to is the guaranteed results in New York Bay, that should be so stated. The question is objected to as being indefinite.

The Commissioner: Note the objection of counsel for the defendants.

A. I must confess that I may be dense, but I do not catch the meaning of the question.

Q. Directing your attention to page 3 of complainants' exhibit No. 135 I ask you to read what stipulations there are made relative to the kind of effluent that would be discharged at Robbins Reef?

3513 Mr. Riker: The question is objected to because it calls for a conclusion and does not call for the reading of the stipulation. The stipulation speaks for itself and should be read with that view.

The Commissioner: Note the objection of counsel for the defendants.

A. (Reading:) "There will be an absence in the New York Bay of visable suspended particles coming from the Passaic Valley sewage.

There will be an absence of deposits objectionable to the Secretary of War of the United States, in the New York Bay, coming from the Passaic Valley sewage.

There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area of elsewhere.

There will be no injury to the public health which will be occasioned by the discharge from the said sewer into the bay of New York in the manner proposed and no public or private nuisance will be created thereby.

The absence of injurious effect from said sewage discharge upon the property of the United States situated in the Harbor of New York."

Q. Now, Mr. Gray, having read the kind of effluent stipulated for in complainants' exhibit 135 and contemplated in that stipulation to be discharged at Robbins Reef, I ask you where that effluent will be produced in the condition that you have now read, and after you have examined the plans of the sewage disposal system on the Newark Meadows?

Mr. Riker: Objected to on the ground that the witness has
3514 not read the kind of effluent that will be produced but on the contrary has read the stipulation which is a stipulation as to results from the effluent and not a description of the kind of effluent.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not understand that I have read a kind or condition of effluent, I have simply read what the results must be.

Q. Where would the effluent be produced?
A. According to this stipulation?
Q. Yes.
A. At the point of discharge.
Q. How about the sewage disposal system, after the sewage is treated in the sewage disposal system, what is about to be discharged, don't you call that an effluent?
A. I should call it the effluent when it comes out of the pipes.
Q. And not when it left the sewage disposal works?
A. Not necessarily.
Q. What change takes place in the matter after it leaves the sewage disposal works and before it reaches the outfall?
A. I cannot tell you.
Q. Do you know of any?
A. I should presume it would be more septicised.
Q. More septicised in New York Bay than in Newark Bay?
A. No sir, that is not what I meant.

Mr. Riker: That was not the question at all.

Q. Where would it be more septicised?
A. Between the points you have already mentioned.
Q. Between the Newark meadows and New York Bay?
A. Newark meadows? I thought you spoke of the Newark Bay a few moments ago.
Q. Do you understand that this sewage will be collected from the entire Passaic Valley and brought to a sewage disposal works
3515 on the Newark Meadows?
A. With the exception of such cities as do not join.
Q. Such cities and townships as do contribute the sewage?
A. That will all be taken in the same trunk sewer.
Q. To the Newark Meadows, is that right?

Mr. Riker: The question is objected to on the ground that it does not state what the witness said, and is not the truth; my objection to the question is that it does not state the facts contained in the witness' testimony.

The Commissioner: Note the objection of counsel for the defendants.

Doctor O'Sullivan: Please read the question?

Q. (Question read to witness as follows: "Such cities and townships as do contribute the sewage, that will all be taken in that trunk sewer to the Newark Meadows. Is that right?"
Do you understand it so?
A. May I read my understanding of it.
Q. Yes.
A. (Reading:' "Upon the line of the Trunk Sewer which it is proposed shall be constructed and at a point at or near the Pumping Station to be located on the Newark Meadows near the Newark Bay, it is stipulated and agreed that the sewage, waste and other matter passing through the said Trunk Sewer shall first pass through coarse screens to remove therefrom all large floating matter, and after pass-

ing through such coarse screens shall pass through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage and other matter shall pass through self-cleansing mechanical screens having clear openings of not over 4/10 of an inch."

Q. Where does all that occur?

A. Where it says.

3516 Q. Where?

A. I will read it again.

Q. I have asked you the location of the plant?

A. On the Newark Meadows.

Q. After being treated by screening, sedimentation and grit chambers what do you call the matter that is about to be discharged; do you call it an effluent?

A. Not taken in connection with this stipulation, no, but in connection with simply these works you mention anything is an effluent that comes from them.

Q. Yes?

A. But it is not an effluent in my judgment in the proper understanding of this stipulation; the effluent will occur when it comes out of the openings.

Q. Will you describe what you mean by the term "effluent" so that we can understand each other?

A. The effluent chamber is a chamber from which the water comes out; the effluent of the works will be the effluent at the works; the effluent of the whole sewerage works will be the effluent at the outlet where these 150 large outlets are.

Q. Do you understand different kinds of effluents, by the description you have given?

A. Oh no.

Q. Do you call the matter that leaves, and is about to be discharged from, the disposal works, an effluent?

A. That is an effluent from the disposal works.

Q. There is one effluent from the disposal works and another effluent from the outfall, is that it?

A. That is it.

Q. What occurs to the effluent that leaves the disposal works before it becomes the effluent at the outfall; what changes occur in its character if you know?

A. In the first place it gets sadly torn up by the pumping.

3517 Q. Yes.

A. Thoroughly mixed, and I have already answered that question by saying that it might be slightly more *speticised*.

Q. If the effluent at the time it reaches the outfall is as good as if is stipulated for in Complainants' Exhibit No. 135, does it make any difference where it is discharged; won't it give the same result?

Mr. Riker: The question is objected to on the ground that there is nothing in the stipulation which says how good or how bad the effluent is when discharged; the only stipulation being as to the result to be produced in New York Bay.

The Commissioner: Note the objection of counsel for the defendant.

A. I do not understand the stipulation states how good the effluent shall be, the quality.

Q. What do you understand those six provisions you read a little earlier relate to?

A. Results.

Q. In what way do they relate to the effluent?

A. The results which the effluent shall or shall not produce on the waters in which it is discharged.

Q. Would those results differ if that effluent was discharged in the lower bay from what they would be if discharged in New York Upper Bay?

A. They might, I do not know.

Q. Have you any knowledge on the subject?

A. No sir.

Q. How would it differ then whether it was discharged in Upper New York Bay, in lower New York Bay or in Newark Bay?

A. I have already said in regard to the two first questions, or the first two parts, I do not know.

Q. How would it differ if it were discharged in New York
3518 Bay or in Newark Bay, if it was the same effluent that is stipulated for in Complainant's Exhibit No. 135?

Mr. Riker: The question is objected to on the same ground that has been urged on several occasions—that the effluent itself is not stipulated for nor described, but the results to be produced in New York Bay only are stipulated for and that it might well be that an effluent to produce those results in Newark Bay would be a very different effluent than the effluent which would produce the results in New York Bay.

The Commissioner: Note the objection of counsel for the defendants.

A. I must claim that I have stated to me what that kind of effluent is; the question I cannot answer, I do not think it can be answered. The results are what are stipulated for and if those same results were obtained in Newark Bay that are stipulated for in New York Bay, why then there would be no difference.

Q. Would you expect the same results from the discharge of the effluent under the stipulation contained in Exhibit 135 if the same treatment was applied as described in Complainants' Exhibit No. 135?

A. I cannot answer that mixed condition; I can simply say that these results called for, if produced in Newark Bay would be the same as in New York Bay.

Q. You have read the whole stipulation, have you not?

A. Yes sir.

Q. Complainants' Exhibit No. 135 I mean?

A. Yes sir.

Q. What objection would there be to discharging the effluent

provided for in this stipulation, what results from that effluent, what objection would there be to discharging that effluent in Newark Bay?

3519 Mr. Riker: The question is objected to on the same ground that has been repeated several times, that the effluent is not stipulated for but that the results are stipulated for.

The Commissioner: Note the objection of counsel for the defendants.

A. I can only repeat what I have said, that the effluent is not stipulated, it is simply the results.

Q. You just heard Mr. Riker make that statement, have you not?

A. I made that statement I think before he did and I have just heard him make it again.

Q. Did you originally make that statement to Mr. Riker?

A. I will say if I did, you have heard it, because all the statements I have made to him, practically, you have heard this morning. I do not remember making such a statement to him.

Q. Do you make a distinction between an effluent and the result of an effluent upon a body of water into which it is discharged?

A. There could be, yes sir.

Q. So that a good effluent might give bad results and a bad effluent give good results, is that it?

A. If you will state some more conditions; I think that a good effluent emptied into drinking water might give bad results.

Q. And a bad effluent emptied into drinking water would give good results, which is the converse of the proposition you stated?

A. Is that a question or a statement?

Q. I ask you if that is so (last question read to witness)?

A. No sir.

Q. Do you make a distinction between the effluent itself and the injury or benefit which may flow from it?

A. Those points are of course considered.

Q. Is any effluent stipulated for in Complainants' Ex-
3520 hibit No. 135?

A. I do not remember that there is, simply the results.

Q. And were those results good?

A. I should think they were.

Q. Would you infer a good effluent from the good results?

Mr. Riker: The question is objected to on the ground that it is indefinite; that in order to answer the question and make it specific it is necessary to state the conditions under which the effluent is to be discharged and the character of the body of water into which it is to be discharged.

The Commissioner: Note the objection of counsel for the defendants.

A. I will add to my other answer by saying I should think they were, for these conditions.

Q. What difference obtains in New York Bay from Newark Bay regarding the reception of such an effluent and its results as are stipulated for in Complainants' Exhibit No. 135?

Mr. Riker: The question is again objected to on the ground that the character of the effluent is not stipulated for in this stipulation and the question therefore is based upon a misstatement of facts.

The Commissioner: Note the objection of counsel for the defendants.

A. I don't know how to answer that question.

Q. Where will the effluent stipulated for in Complainants' Exhibit No. 135 be produced?

A. There is none stipulated that I know of.

Q. What matter gives the results that are called for in Complainants' Exhibit No. 135 and at page 3 of that exhibit?

Mr. Riker: The question is objected to on the ground that it is not directed to any particular matter and therefore is obscure and incapable of being answered.

2521 The Commissioner: Note the objection of counsel for the defendants.

Q. It has no relation to a sewage effluent, has it?

A. It states what the results of that sewage effluent shall produce and shall not produce.

Q. Where does it use the word "effluent"?

A. In those six paragraphs?

Q. The word "effluent" where does it occur?

A. You mean in those six paragraphs?

Q. Anywhere in the stipulation?

A. I fail to find that the word is used.

Q. What does the whole stipulation relate to, meaning the stipulation your attention is now directed to, being Complainants' Exhibit No. 135?

Mr. Riker: Objected to on the ground that the stipulation, being a document in evidence, speaks for itself.

The Commissioner: Note the objection of counsel for the defendants.

A. That is very indefinite; it might relate to quite a few things; the main point is the disposal of the sewage through this Trunk Sewer.

Q. Does not the whole stipulation as you understand it relate to the treatment that sewage will receive before it is discharged into New York Bay and the product or effluent from that treatment?

A. Not that alone, it relates to the results that that will produce, also.

Q. The results from what?

A. From the discharge of such sewer into the bay of New York.

Q. What will be discharged from those multiple outlets?

2522 A. What we have been calling an effluent?

Q. Where is that effluent produced?

A. Its final production is at the discharge of these 150 outlets.

Q. Does it receive any treatment after leaving the sewage disposal works on the Newark Meadows, under that stipulation?

A. I have several times said that the only change I can conceive of is that it may be slightly more septicised.

Q. And that would be a change for the worse?

A. I do not think so.

Q. You think sewage is better when it is septic than when it is fresh?

A. I think the effluent from septic tanks is more easily treated oftentimes than fresh sewage.

Q. Yet I understood you to say a little while ago that you did not know whether the septic sewage demands more oxygen and exhausts the oxygen contents of water more than fresh sewage?

A. I do not remember having made that statement.

Q. I put it to you as a question, does fresh or septic sewage more rapidly exhaust the oxygen contents of water into which either or both are discharged?

A. I should look for the septic sewage as rather more quickly taking up the oxygen.

Q. What kind of an effluent under the plans that you have been studying regarding the Passaic Valley Trunk Sewer project and the sewage disposal works and the treatment that the sewage would receive would be produced?

A. An effluent which I think would give those results.

Q. And that effluent would be produced, at the works?

A. As I have just stated, the final effluent would be produced—discharged—at the outlets.

Q. The final effluent?

A. Yes, sir.

3523 Q. But the effluent produced at the works, would that effluent give the results stipulated for in complainants' exhibit No. 135?

Mr. Riker: Objected to on the ground that the witness is asked to guess as to conditions which are not in the case and are not in existence; the effluent produced at the works is not the effluent to be discharged at the point near Robbins Reef but that is an effluent discharged through an outfall sewer with multiple outlets, at a certain depth of water.

The Commissioner: Note the objection of counsel for the defendants.

A. I think the effluent which would be discharged from the outlets will produce the results enumerated in the stipulation.

Q. I will repeat my question. (Last question read.)

A. I want to answer your question, I want to answer it freely, but there is no effluent stipulated. When you are speaking of the effluent, that means the material discharged from the sewer, all that is stipulated with regard to that effluent is what the results of it shall be under those conditions, emptied as they propose.

Q. You have studied the sewage disposal system contemplated to be erected on the Newark Meadows, have you not?

A. In the way that I have stated, yes sir.

Q. What kind of an effluent would those works produce?

A. I cannot give you any different answer than what I have said; they will produce an effluent that will give those results.

Q. If that effluent produced at the works and yielding the results you have just stated would be equal to those stipulated for in complainants' exhibit No. 135, would such an effluent injure Newark Bay if discharged into it?

A. I cannot say.

Q. Would you expect injury from it?

3524 A. I cannot say, I cannot answer that question.

Q. Would you expect such effluent to contain visible suspended particles?

Mr. Riker: I object to the question on the ground that it is indefinite in that it does not specify where, the point at which, or the conditions under which it might produce visible suspended particles.

The Commissioner: Note the objection of counsel for the defendants.

Q. (Last question read.) If discharged at the most favorable point in Newark Bay?

A. Without having studied it with reference to that point of discharge, I cannot say.

Q. Would you expect, with such an effluent discharged at the most favorable point in Newark Bay that there would be an absence of deposits objectionable to the Secretary of War?

A. My answer to that would be the same as my answer to your last question.

Q. Would you expect from such an effluent the absence of odors at the point of discharge or in its vicinity when discharged at the most favorable location in Newark Bay?

A. I make the same answer.

Q. Would you give the same answer to the fourth stipulation as to the results relating to grease or color and under the same conditions?

A. Yes sir.

Q. And you would make the same answer, would you, to the fifth item of the stipulation regarding injury to public health under like conditions as I have just embodied in my other questions?

A. Yes sir, with this to be said, that the conditions are very different; I should give the same answer.

Q. Directing your attention to the sixth item of the stipu-

3525 lation on page 3 of complainants' exhibit No. 135, assuming the same condition of facts, would your answer be similar in regard to the absence of injurious effects from such sewage discharge upon the property of the United States or otherwise?

A. I should have to to know more fully the location of the property of the United States, which I am not familiar with.

Q. Or other property in the vicinity of Newark Bay—substitute "other property" for "United States property"?

A. Private property?

Q. Yes.

A. My answer would be the same as before, to the other five.

Q. Assuming the same condition of facts would you expect absence of reduction in the dissolved oxygen contents of the waters of Newark Bay resulting from the discharge of this effluent that we have been discussing?

Mr. Riker: Objected to on the ground that there is no stipulation anywhere in regard to the actual quantity of dissolved oxygen and that the question is not based, as a hypothetical question, upon any facts in this case.

I want the witness to have his attention directed to the stipulation and that the dissolved oxygen relates to major fish life and not to the actual quantity of dissolved oxygen.

The Commissioner: Note the objection of counsel for the defendants.

A. The last question regarding the 7th is more difficult than any of the others. I should give the same answer however to No. 7 as I have to the six preceding ones.

Q. Would that effluent after it left the sewage disposal works on the Newark meadows be improved in any particular in its transit to the multiple outlets in New York Bay?

A. I think I have answered that question several times; it
3526 might be slightly more septicised.

Q. Would you regard that as an improvement?

A. Leaning that way, yes sir.

Q. Although it would exhaust oxygen more rapidly than if it were not so septic?

A. I have stated, sooner, but I have not stated that it would absorb more oxygen than the fresh sewage, take it up quicker.

Q. How does fresh sewage absorb oxygen?

A. I don't know, I am not a chemist.

Q. Don't you know that is not a chemical question?

A. No sir.

Q. Don't you know that it is a biological question?

A. Partly it may be, but I am not a biologist.

Q. Do you know which of those two——

A. I will have to let you state that.

Q. In 1902 when you made your examination of the Passaic River were you not in favor of the discharge of sewage into the Newark Bay?

A. I do not remember that I was, and if the plan at that time contemplated discharging it into Newark Bay I recommended Paterson to join the trunk sewer rather than put up works of their own.

Q. And did not they call upon Mr. Hazen later to make a report and did he not substantalally make a report that they ought to dispose of their own sewage in preference to entering into the trunk sewer scheme.

Mr. Riker: The question is objected to on the ground that the answer would necessarily be hearsay and that if Mr. Hazen's report is material to this case it should be proved regularly.

The Commissioner: Note the objection of counsel for the defendants.

A. My answer was going to be just what Mr. Riker has given, I only know it by hearsay, I have no evidence of it.

3527 Q. Was the report you made to the City of Paterson published?

A. No sir, not that I know of, I cannot say.

Q. Was it an oral or a written report?

A. It was a typewritten report.

Q. That was in what year?

A. The latter part of 1902 was the examination, most of it, and the report was published, I think in 1903, the early part.

Q. Do you remember what the date of Mr. Hazen's report was?

A. No sir.

Q. Do you know whether that was printed or not?

A. I do not.

Q. Have you seen a copy of Mr. Hazen's report that you know of?

A. Not that I remember.

Q. Have you ever studied any report in relation to the Passaic Valley trunk sewer scheme, and separate disposal systems for the Passaic Valley water shed?

Mr. Riker: The question is objected to on the ground that it does not appear there are any such.

The Commissioner: Note the objection of counsel for the defendants.

A. It seems to me the question is, if you will excuse me for saying so, contradictory, I do not understand what you want to express to me.

Q. You fail to understand my question?

A. Yes sir, I do.

Q. Have you read any reports for any scheme of sewage disposal in relation to Passaic Valley, or any of its municipalities?

Mr. Riker: The question is objected to as not being cross examination, and immaterial and irrelevant in any view.

The Commissioner: Note the objection of counsel for the defendants.

3528 A. Do you mean disposal of separate municipalities?

Q. Either for separate disposal or for a trunk sewer scheme.

A. All I have read is my own report and portions of what Mr. Herring made.

Q. How long ago was that?

A. My report, as I have said, was made in 1903; I do not remember that I have read it since; it was several years since that I read Mr. Herring's report, I cannot say how long since.

Q. Before 1906, was it not?

A. I would not undertake to fix the date.

Q. Do you recall enough of his report to say whether or not it contemplated the discharge of crude sewage?

A. I do not remember.

Q. Did you ever read the Passaic Valley Sewerage Commissioners report, or any of their reports?

A. I think I have; I have read what I should suppose you meant by that, a report to his Excellency Franklin Murphy, dated June 8, 1903, in which are also gathered reports from various other parties.

Q. And that was the last of the reports that you have read, was it?

A. I do not know.

Q. Do you not recall any others?

A. No, sir, I do not recall whether I did or not.

Q. Will you say positively that there were others than the one which you have just produced?

A. No, sir, I won't say either way positively.

Q. How many towns and municipalities is this trunk sewer project contemplated to serve?

A. I cannot state the number, but those bordering on the Passaic Valley, with the exception of a few, my impression is three or four possibly.

Q. Do you know whether that trunk sewer project of the
3529 Passaic Valley Sewerage Commissioners contemplates serving those communities for the dry weather flow or for storm and dry weather flow?

A. I understand it is for the dry weather flow plus more or less ground water which would inevitable get into the sewers, plus possible the first flush of a storm, but not what we would term storm sewers.

Q. What is the precipitation of the Passaic Valley water shed?

A. I cannot tell you now; I have had that; I should think in the neighborhood of forty odd inches, but — is so long since I dealt with that that I do not remember.

Q. Are you familiar with the number of rainy days they have here, with the general conditions of precipitation?

A. In a general way, but I could not tell you how many rainy days they have here.

Q. What percentage of the flow will this trunk sewer project accommodate during an ordinary wet day along the Passaic water shed?

A. I cannot tell you, I do not know.

Q. Will it be able to handle ten per cent of it?

A. I don't know.

Q. What percentage of the trade wastes is it contemplated will be carried in this trunk sewer?

A. I understand generally the total wastes, with the understanding that that waste is to be reduced as far as it can be by the manufacturers.

Q. What percentage of that?

A. I cannot tell you the percentage.

Q. Don't they take all of it?

A. Just as I have said, I understand they take the waste less what they can prohibit going into the sewers, without injury.

Q. What provision is made in the Passaic Valley trunk
3530 sewer project for the surplus during a rain storm?

A. Surplus of what?

Q. Of flow.

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. Do you mean the surplus of the rain fall?

Q. Yes, the rain fall and sewage; they get mixed, do they not?

A. Yes.

Q. How do they handle that surplus if this project is calculated to deal with the dry weather flow?

A. As I have stated the first flush of the storm as I understand will be taken in the trunk sewer; what may come from the district will go into the Passaic River.

Q. Will go right into the Passaic River?

A. I so understand it.

Q. And that would be a mixture of sewage, trade wastes and storm water?

A. It would to that extent, but a very much diluted extent.

Q. It would be sewage and trade waste diluted.

A. That is what I have said.

Q. Would you expect the first flush of a storm always to go into this trunk sewer?

A. I do not see why it would not.

Q. After it had been running awhile they would have to let out the accumulated sewage, trade waste and storm water at various outlets into the Passaic River itself; is that correct?

Mr. Riker: The question is objected to on the ground that it relates to conditions existing in the State of New Jersey, and has no relation to the issue which is the supposed threatened creation of a nuisance in New York Bay.

3531 The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: Counsel for complainant- presses this line of questioning because it tends to show that this trunk sewer project will not be sufficient for the purposes contemplated in its very design, and will not reduce the offensive condition already existing in the Passaic River.

Mr. Riker: Counsel for the defendants rests his objection to the question on the ground that it is none of the complainants' business whether it will or will not; it is an impertinent inquiry.

A. Answering the question, which is comprehended in three words "is that correct" relative to the statement which I understand you to have made, I should say that I do not know.

Q. You made a distinction a little while ago between the effluent

which left the sewage disposal works on the Newark meadows, and the effluent that was to be discharged from the multiple outlet in New York Bay; how do you understand that effluent from the Newark meadows was to be transported to New York Bay?

A. May I first ask what distinction I made; I do not remember?

Q. Your distinction, as I remember it was, that it would be more septic.

A. Slightly more; as I understand, that sewage is to be transported in a tunnel sewer, or whatever name you may give it.

Q. What is to be the construction of that channel of transportation?

Mr. Riker: The question is objected to as irrelevant, immaterial and impertinent.

The Commissioner: Note the objection of counsel for the defendants.

3532 A. I cannot recall the details of that construction.

Q. Was it to be brick?

A. My recollection of it is that some of it was.

Q. Mostly brick.

A. Well I cannot say as to most of it, some of it was iron pipe, as I recollect.

Q. Iron pipe and brick; do you know how long the tunnel made of brick and iron, that is to transport this——

A. No, I cannot discriminate.

Q. How was it to lay in regard to Newark Bay, a little below the *d*urface, or on the surface?

Mr. Riker: I object to the question on the grounds last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. The impression I had is that it is to be laid sufficiently deep to be out of the way of any future improvement which may be made to the harbor.

Q. How was it to be carried across the Bay, on the pen*n*insular?

Mr. Riker: I enter the same objection.

The Commissioner: Enter the objection of counsel for the defendants.

Q. With brick or iron?

A. Across the Bay, on the pen*n*insular?

Q. Yes.

A. I do not remember.

Q. Then after it reached New York Bay it would dip deep enough into the water to give it a forty foot discharge, is that right?

A. I so understand it.

Q. Do you know what percentage of the entire expense of the Passaic Valley trunk sewer project that mode of conducting the effluent from the Newark Meadows to New York Upper Bay

3533 would represent?

Mr. Riker: Objected to on the ground that it is irrelevant,

immaterial and impertinent; does not concern this complainant and is not related in any way to any issue in this cause, and the witness is privileged under the advice of counsel not to attempt to answer.

The Commissioner: Note the objection of counsel for the defendants.

Witness: Am I to answer that, your Honor?

The Commissioner: You may do as you please.

A. I do not know.

Q. How many outlets are there for the overflow from the trunk sewer, do you know, between Paterson and Newark?

Mr. Riker: I make the same objection as last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. No sir.

Q. Do you know whether or not there are fifty?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not know.

Q. A little earlier in our discussion we found that you had discarded the chemical mode of precipitation as a method of sewage disposal; is the general practice now to discard the septic tank as well as the chemical method of sewage disposal?

Mr. Riker: Objected to on the ground that this witness is testifying under oath in answer to questions and is not discussing anything with counsel for the complainant, and therefore, the question ought to be stricken from the record.

The Commissioner: Note the objection of counsel for the 3534 defendants.

A. It is news to me that I have discarded that method, when that method would be the best.

Q. The chemical precipitation?

A. I have not stated that I have discarded it in any of my testimony.

Q. You installed it in Proidence, and I understood you to say it has been discontinued.

A. You entirely misunderstood my answer.

Q. Where did you install it?

A. At Providence.

Q. And it is still in use there?

A. Certainly, every day.

Q. Chemical precipitation?

A. Yes, sir.

Q. Is the general practice among sewerage disposal operators in favor of or against chemical precipitation?

A. I think there are not as many enthusiastically in favor of it as there were many, many years ago.

Q. How would you say as to septic tank treatment?

A. What do you mean, that question is very indefinite to me?

Q. Is that a favorite method, to dispose of sewage by the septic tank method, now, or is it in disfavor?

A. The Cameron people think it is very acceptable, they are very much in favor of it, and many engineers are today; some are not as enthusiastic about it as they were a few years ago.

Q. How are you individually?

A. I want to see the place, and then I will answer.

Q. Is the effluent from a septic tank more easily or less easily treated, than the effluent such as is described in complainant's exhibit No. 135?

A. Treated how, by what method?

3535 Q. By any method?

A. I cannot answer a question as indefinite as that.

Q. What kind of an effluent does a septic tank yield?

Mr. Riker: I object to this question until the witness be informed as to what the septic tank is and what the sewage treated by it is; the question is not made definite enough for him to answer.

The Commissioner: Note the objection of counsel for the defendants.

A. If I know what you mean by "such kind" I will try to answer your question.

Q. Have you ever had any experience with septic tanks?

A. Yes, sir.

Q. Where.

A. For the state institutions of Rhode Island.

Q. What is the object of septic tank treatment?

A. The treatment of sewage has been something like the development of the locomotive, little by little, changing and changing; it is something like the development of the practice of medicine and surgery, improvements from year to year. The septic system was an advance in some places over chemical precipitation; where land could not be obtained in sufficient quantities for sand filtration it has been adopted, filtering the effluent afterwards with more ease and less labor than you could filter the crude sewage. I do not know how far you want me to keep on with the several steps.

Q. The mere fact that there are stages is what I was after.

A. Yes, everything goes in stages, whether it is theology or whether it is medicine, or whether it is mechanics. I was going to add that just now——

Q. What I was getting at is this; is it not a fact that chemical precipitation was fairly popular in this country and is it

3536 not now somewhat obsolete, having been succeeded by the septic tank which in its turn has also become obsolete?

A. I cannot say yes to that; I will say, however, that it was more popular years ago than it is today, but I will not admit that neither is obsolete. I was about to add that the next step from the septic

takn was the Imhoff tank which is supposed to be somewhat of an improvement.

Q. But the general trend of the profession is to get away from the septic tank now, is it not?

A. I could not say that it is, I would not be so emphatic as that.

Q. How long is it since you have built or installed any large sewage disposal system?

A. I have just now, within a few weeks, completed one for Albuquerque, New Mexico, quite a system.

Q. What is the populaton there?

A. I am not positive, I should think thirty or forty thousand. I have more recently installed and built some ninety miles in San Antonio, Texas.

Q. For what population to be served?

A. My recollection is it was nearly one hundred thousand. I have recently been consulted with regard to the Worcester sewage, the population there amounting to about one hundred and fifty thousand.

Q. One hundred and fifty thousand in San Antonio, Texas?

A. No, Worcester, Massachusetts.

Q. Did you design and build those works there?

A. No, sir. Part of them, yes sir, and part of them, no sir. As stated in the early part of my testimony I was appointed as one of three to design the reconstruction of those sewers, and the reconstruction of the works for the disposal of the sewage.

3537 Q. Who did the major part of those works at Worcester?

A. Mr. Allen, in the early part, Mr. Charles Allen.

Q. Was Mr. Eddy connected with them?

A. Yes, he was, concerned in the sewer, for quite a while, but Mr. Allen was City Engineer.

Q. You have said you have read some of the testimony; whose testimony did you read that has been given in this case?

A. I can give you the names but I do not think I can separate the testimony; some of it was given by Mr. Eddy, some by Dr. Mason of Troy, and I think by Mr. Hayden, some of it, and some by Mr. Fitzgerald.

Q. Who is Mr. Fitzgerald?

A. He was engineer of the water works in Boston for a good many years.

Q. Did you know him when he was president of the American Society of Civil Engineers?

A. Yes, sir.

Q. Who is Dr. Mason?

A. He is at the head of the Polytechnic Institute at Troy.

Q. An eminent man?

A. Yes, sir.

Q. Did you read any of Mr. Eddy's testimony?

A. I did, as I said I do not know as I could distinguish what each testified to.

Q. Do you regard Mr. Eddy as a very able man?

A. Mr. Eddy is an able man.
Q. Did you read any of Professor Sedgwick's testimony?
A. Yes sir, I read some of that.
Q. Who is Professor Sedgwick?
A. He is connected with the School of Technology at
3538 Boston.
Q. At the head of the Massachusetts Institute of Technology?
A. Yes sir.
Q. Do you regard him as an eminent sanitarian?
A. Why yes.

A recess was then taken.

Redirect examination by Mr. Riker:

Q. Your knowledge of trade wastes in the Passaic Valley district was obtained in connection with your report to the City of Paterson, was it not?
A. Yes sir.
Q. And in the consideration of a separate disposal plant for Paterson did you or did you not plan to take care of that trade waste?
A. Some of it yes sir, particularly the wool washings.
Q. Assuming that all of the trade waste in this district are to be excluded from the sewer except ten per cent, in your opinion will that be any factor in the effluent as discharged into New York Harbor?
A. You refer to all the manufactories in the valley?
Q. Yes, all but ten per cent is removed.
A. I do not think it will be any serious factor at all.
Q. You testified on cross examination that the removal of the solids that will be accomplished by the works proposed on the meadows, in connection with the Passaic Valley sewer, in your judgment will remove a part of the pathogenic germs in the sewage?
A. Yes sir.
Q. Is there any process of distroying the pathogenic germs that could be applied at the tanks on the meadows when in operation?
3539 A. Yes, soda ash, or some such chemical.
Q. A germicide could be applied in the tanks?
A. Yes sir.
Q. Do you know whether sewage moving at the rate of three feet a second will become septic more quickly or less quickly than sewage that is in a state of rest?
A. I should say less quickly.
Q. Do you know the rate of discharge estimated for the sewage in the Passaic Valley sewer?
A. I do not remember.
Q. You have made some observations in the past as to the condition of the Passaic River above Newark, I think you said?
A. Yes sir.

Q. And I think you said that you found septic conditions existing there?

A. Partially, approaching that—the beginning.

Q. What is the dilution of the sewage discharged into the Passaic River, by the waters of the river at Newark; considerable or inconsiderable as compared with the dilution in New York upper bay?

A. Comparatively I should say very much less.

Q. And has that less amount of dilution any relation to the conditions you found or observed at Newark in the Passaic River, with relation to the septic condition of the river?

A. Do you mean by that question the effect of those works on the sewage in the Passaic River?

Q. No, I mean by that to ask you whether the inconsiderable dilution of the sewage discharged into the Passaic River was a factor in the resultant septic conditions that you have observed?

3540 A. Yes sir.

Q. Given a definite sewage discharge, or a discharge of liquids contaminated with organic matter, will the discharge of that sewage matter into a large body of water in your opinion be attended with different results from what it would be attended with when discharged into a comparatively small body of water?

A. Yes sir, because it would dilute it more.

Q. If discharged at a depth of forty feet, in your opinion would that have any results as to the observed consitions produced by it, different from a discharge at a depth of fifteen feet?

A. Yes sir, it would.

Q. You produced in answer to a question a report; I wish you would look at this pamphlet, which I now hand you, and tell me whether that is a duplicate of the report that you produced upon being asked with regard to certain reports on your cross examination?

A. Yes sir.

Mr. Riker: I offer that in evidence and ask that it be marked. It is a special report of the Passaic Valley Sewerage Commissioners, to the Governor of the State of New Jersey, submitted June 8, 1903.

The Commissioner: Let it be marked.

(Marked Defendants' Exhibit No. 1.)

Recross-examination by Dr. O'Sullivan:

Q. What is the present dilution in the Passaic River for the sewage and trade wastes discharged into it, what is the ratio of dilution?

A. I cannot say, I do not remember.

3541 Q. Can you approximate it?

A. No sir.

Q. So that your answer on that question was a guess, was it?

A. I do not remember guessing at anything.

Q. If you do not know the ratio of dilution how can you answer the question on the precent dilution of the sewage and trade wastes discharged into the Passaic River?

A. May I ask which question you refer to and hear it read? I

think I understood the questions before I answered them and I certainly do not remember doing any guessing.

Q. Do you or do you not know the ratio of pollution now in the Passaic River for the sewage and trade wastes discharged into it?

A. No, sir, I do not.

Q. Do you know anything about the tidal phenomena in the Passaic River?

A. No sir. I have known it but there have been so many matters since that I cannot recall the conditions.

Q. Have any float observations made on the Passaic River ever been submitted to you?

A. No sir.

Q. To what do you now attribute the septic condition of the Passaic River?

A. To the sewage discharged into it and the time it remains in the river.

Q. How long does it remain in the river before entering Newark Bay?

A. I do not know.

Q. Have you any general idea or approximate idea?

A. No sir.

Q. In considering the question of dilution by a body of water into which sewage is proposed to be discharged, do you take into the consideration the present polluted condition of that body of
3542 water in order to determine whether or not you would get the measure of dilution that you think would be desirable?

A. You refer to the pollution from New York City as well as the Passaic Valley?

Q. Yes, I am dealing with the body of water itself, no matter where the pollution comes from, into which you contemplate discharging a large volume of additional sewage.

A. Yes sir, I think of that, and yet believe that the treatment given this sewage would produce the results stated in the stipulation.

Q. What is the condition of New York upper bay now with regard to pollution?

A. That I testified to before as being not a desirable condition but a far better condition than most streams into which sewage is emptied, particularly in such quantities.

Q. How long does it take sewage to leave New York Bay that has been discharged into it, and go through the narrows?

A. I have not the records of that, I could not say.

Q. Your observations of New York's upper bay, as I gather from your testimony, were confined to your visual inspections from the decks of the Fall River steamers, is that right?

A. No sir, that is not quite right; the visual part is right, and the additional part would also be right, but not as confined to Fall River steamers, for I very seldom take those steamers. I have been up the Hudson River to Albany many times; I have been across it in ferries many times, and have been through the river in the Providence line of steamers many times, and I have been to Coney Island and thereabouts, and noticed conditions.

Q. But your observations were made from these steamers you have mentioned?

3543 A. Yes sir.

Q. You have never made any attempt to determine the oxygen contents.

A. No sir.

Q. Nor made any other examinations than you have described, the visual and the *olofactory*?

A. No sir.

Q. I did not quite catch what you said about the ten per cent of the trade wastes; were they to remove ten per cent, or all but ten per cent, which was it?

Mr. Riker: The question was removing all but ten per cent, Doctor.

Q. How is that ninety per cent to be removed?

A. That was not stated to me. The question was asked me—if it was so and so, then what; and it was not told me how that was to be removed.

Q. Do you understand whether or not the trade wastes are to be taken in this trunk sewer

A. I understand more or less of them are.

Q. Approximately how much?

A. I cannot tell you.

Q. Would you say ninety per cent?

A. I would not say for I do not know, I would not express an opinion.

Q. Any data submitted to you did not convey to you the idea of how much of these trade wastes were to be transported in the Passaic Valley trunk sewer project?

A. I got an impression that a large proportion would be conveyed; I cannot say that impression was gained from absolute figures.

Q. And that was approximately ninety per cent?

A. I did not formulate any opinion as to the exact per-

3544 centage.

Q. Do you know what the flow is in the Passaic River?

A. No sir.

Q. Just one question about defendant's exhibit No. 1; did you contribute any of the material that is contained in that special report of the Passaic Valley Sewerage Commissioners, known in this case as defendants' exhibit No. 1, and dated June 8, 1903?

A. In the Commissioners' Report you say?

Q. In this exhibit.

A. Yes, sir, but what about it?

Q. I ask you if you contributed any of the material for it?

A. I do not think I did.

Further redirect examination by Mr. Riker:

Q. I want to ask you one other question with reference to these results which are stipulated for in complainant's exhibit No. 135,

being the agreement between the United States and the Passaic Valley Sewerage Commissioners and the State of New Jersey; in your judgment will there or will there not be created a nuisance in New York Harbor?

A. I think there will not, I do not see how there can be.

Further recross-examination by Dr. O'Sullivan:

Q. I understood you to say that the effluent as it reached the outfall pipes would be more septic than when it left the disposal works; how do you account for sewage that is septic not causing a nuisance?

A. My answer was it might be slightly more septic.

Q. Would septic sewage discharge sulphurated hydrogen?

A. I think there might be a trace of it.

Q. What do you mean by a trace?

3545 A. Nothing that would be objectionable.

Q. How would you detect a trace, you yourself?

A. I would go down there and smell of it.

Q. There is no chemical method that you could determine it by?

A. I could not myself, I do not say there is no method.

Q. The evidence that you mentioned a little earlier, that you had read, given by Professor Mason and Professor Sedgwick and Mr. Eddy, and the other gentlemen you have mentioned, did you read that they had found there would be a nuisance created?

Mr. Riker: Objected to on the ground that their evidence speaks for itself, and is in the case, and that this witness's knowledge of it is not competent.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: Complainant's counsel presses the question for the reason that it tests the memory of this witness.

A. As I remember their evidence they thought there would.

Q. Do you recall that they expressed an opinion that there would?

Mr. Riker: I enter the same objection as before.

The Commissioner: Note the objection of defendants' counsel.

A. I do not recall they positively expressed an opinion that such was the fact.

Q. Is colloidal matter putrescible?

A. I do not know, I am not a chemist.

Q. Is there any provision for removing colloidal matter in complainant's exhibit No. 135?

3546 A. Only what is there stated in regard to the treatment of it, that might remove it.

Q. Do you know whether or not colloidal matter is highly putrescible?

A. No sir.

GEORGE S. GREENE, JR., a witness produced on the part of the defendants, being duly sworn by the commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you live?
A. New York City.
Q. What is your profession?
A. Civil Engineer.
Q. How long have you been practicing that profession?
A. About fifty years.
Q. What education or experience have you had in your experience?
A. After I finished high school education I went to Harvard for a while, but I did not graduate. I left before graduation, and studied civil engineering in the office, and under the direction of my father.
Q. Who was he?
A. General George S. Greene.
Q. Are you connected with any scientific societies?
A. I am a member and past vice president, of the American Society of Civil Engineers, and an honorary member of the Institute of American Architects.
Q. Give some of the work you have been engaged in in your profession since you have been practicing it.
A. I was for a number of years an assistant engineer in the Croton Water Works department, and then for a time, for
3547 a few years, I had an office of my own for general work, and also was making extensive surveys under contract in the annexed district. In 1875 I was appointed engineer in chief of the Department of Docks in New York City, which position I held until January 1898. Since then I have had an office for general work and have done work as a consulting engineer, and also some expert work in the valuation of water front property. At present I am engaged as a consulting engineer.
Q. What opportunities for the observation of harbors have you had?
A. As engineer in chief of the Department of Docks our water front, the water in it as well as the structures, were under my charge and supervision constantly, and I observed the condition of the water at various points with regard to the surface of the harbor.
Q. Have you had any special training in chemistry?
A. No sir.
Q. In bacteriology?
A. No sir.
Q. Will you give such observations as you have made of the character of the waters in New York harbor.
A. My observations were in the slips and out in the current, in the main channel, in the fairway, frequently, not to say constantly, and to observe, and when I could correct, the discharge of improper material, sewage matter for instance, into the waters of the harbor. That is, when the sewers ended at the bulkhead, the boundary line

between the land and the water, sewage, fœcal matter, and other matters, from the sewers, would collect; but as we went along making improvements to the water front, we would carry the sewers out to the ends of the piers, where they would discharge into more
3548 of the current, water moving more quickly, and in such cases, there was very little to be seen of the results of the discharge of the sewers.

Q. What acquaintance have you had with the project of the Passaic Valley Sewerage Commissioners, and when did you make that acquaintance?

A. In 1902 or '03 I was asked to read Mr. Herring's report, and asked if I thought his proposition—what he proposed to do—would be any detriment or create any nuisance in the harbor of New York. I did so, read Mr. Herring's report, looked up some points of information and made a report.

Q. Do you know whether that report is embraced in the pamphlet which is defendants' exhibit No. 1?

A. Yes sir, it is.

Q. The report of Mr. Herring, upon which you made your report, have you that with you?

A. Yes sir.

Q. Did the proposal upon which you made your report, which is embodied in defendants' exhibit No. 1, involve any purification of the sewage of the Passaic Valley sewer?

A. Yes sir.

Q. What purification was contemplated at that time?

A. It was to be screened and allowed to settle, those are the principal things; they were to put up some sort of skimmers also to take any floating matter that would be on the surface of the sewage passing through the sedimentation boxes or tanks.

Q. Where was the point of discharge contemplated, upon which you based your report?

A. At the same place as at present, that is near Robbins Reef Light, in a depth of forty feet of water.

Q. And through one outlet or through multiple outlets?

A. I think it was several.

3549 Q. Have you read the stipulation which is complainants' exhibit No. 135, a stipulation between the United States Government and the State of New Jersey and the Passaic Valley Sewerage Commissioners?

A. Yes sir.

Q. I hand you the original exhibit and ask you to look at it and see if you are familiar with the contents of the stipulation.

A. (After examining Exhibit No. 135.) Yes sir.

Q. In your opinion will the discharge from the Passaic Valley sewer, subjected to the purification processes described in that stipulation, and discharged as described in the stipulation, produce the results in the waters of New York Bay which are contained in that stipulation?

A. I think so, yes sir.

Q. And if those results are obtained or appear from the sewage

discharged as described and treated as described, will there in your judgment be created any nuisance in New York Bay?

A. No sir.

Q. Do you base your answer upon chemical considerations?

A. No sir.

Q. Do you base it upon bacteriological considerations?

A. No sir.

Q. What do you base your answer upon?

A. Dilution.

Q. What knowledge have you of the dilution capacity of Upper New York Bay?

A. My answer would be largely figures which I cannot carry in my mind. Is it permissible for me to read them?

Q. Certainly, sir, refresh your memory from whatever will refresh it.

Dr. O'Sullivan: One moment, what are you consulting now?

Witness: A copy of my report made in 1903.

3550 Dr. O'Sullivan: Which is in evidence here in defendants' exhibit No. 1?

Witness: I think so, yes sir.

Dr. O'Sullivan: At what page?

Witness: I am looking now at page 8.

From the United States Coast Survey Report of 1896 I obtained the following:

Tidal Flow New York Harbor.

Epitome of Results for Discharge 25th June, 1886.

East River (19th Street):

	Cubic feet.
Ebb (westerly)	4,454,937,257
Flood (easterly)	4,007,175,676
Excess of ebb	447,761,581

Hudson River (39th Street):

	Cubic feet.
Ebb (southerly)	6,996,678,413
Flood (northerly)	6,225,985,545
Excess of ebb	770,692,868

Kill von Kull (West New Brighton):

Ebb	1,790,103,372
Flood	1,712,415,362
Excess of Ebb towards the harbor	77,688,010

Narrows:

Ebb (seaward)	13,819,895,144
Flood	12,703,616,481
Excess of Ebb	1,116,278,663

I also take the following from the same report.

	Cubic feet.
Fresh water discharge of Hudson at 39th Street Aug. 11, and 12, 1865	385,346,424
Fresh water discharge of Hudson at Dobbs Ferry Aug. 19 and 21, 1865	373,426,507

That is the data I had.

3551 Q. Have you a basis of determination of the safety of discharge of sewage into water based upon dilution?

A. No sir.

Q. What did you calculate as a safe basis?

A. I do not calculate, I have not at least calculated what is a safe basis, but when I find there is a certain basis a small one, I consider that that is perfectly safe.

Q. Taking the diluting power of New York Bay as you have determined it from the figures which you have examined what, in your opinion, will be the effect of the discharge of an effluent or a sewage discharge, treated as specified in this stipulation, into the waters of upper New York Bay?

A. I think it will be hardly perceptible, to the senses I mean, such as smell or sight.

Q. Do you think there will be an absence in New York Bay of visible suspended particles coming from the Passaic Valley Sewage?

A. I think so.

Q. Do you think that there will be an absence of deposit which should be objectionable to the Secretary of War of the United States, in New York Bay, coming from the Passaic Valley Sewage?

Dr. O'Sullivan: Objected to as clearly beyond the purview of this witness's knowledge.

The Commissioner: Note the objection of counsel for the complainant.

A. Absence of something coming from the sewers?

Q. Absence of deposits objectionable to the Secretary of War of the United States, in New York Bay, coming from the Passaic Valley Sewage?

A. I think there will be no deposits coming from that sewage that the Secretary of War should object to.

3552 Q. Do you think that there will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matter contained in the Passaic Valley sewage?

A. I do.

Q. Do you think there will be a practical absence on the surface

of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere?

A. I think so.

Q. Do you think that there will be any injury to the public health which will be occasioned by the discharge from the said sewer into the bay of New York in the manner proposed or any public or private nuisance created thereby?

A. No sir.

Q. Do you think there will be absence of injurious effects from said sewage discharge upon the property of the United States in the harbor of New York?

A. Yes sir.

Q. Do you think that there will be an absence of reduction in the dissolved oxygen contents of the waters of New York Bay resulting from the discharge of the Passaic Valley sewage to such an extent as to interfere with major fish life?

A. That I don't know and don't understand.

Q. In case the sewage treated as specified in this stipulation by the works and processes therein particularly described should not result when discharged in New York Bay as is guaranteed in the stipulation, are there other processes which you know of which could be added, and which would be efficient in producing such a result?

A. Well, there is the extreme process of sand filtration which might be resorted to to make the water fit for drinking, as is done in Poughkeepsie and several places? If there are some minor
3553 defects, some small failures to accomplish all these results stipulated, they might be overcome by keeping certain substances out of the sewer.

Q. Directing your thought now to the subject of trade wastes would or would not in your judgment the exclusion of them, at the point of production, so that they did not reach the sewer at all, have the result of increasing the purity or clarity of the effluent?

A. I should think it would yes sir.

Q. What in your judgment will be the result on the waters of upper New York Bay of the discharge of sewage treated as is described in this stipulation, compared with the conditions which result from the discharge of the waters of the Passaic River and Newark Bay into the upper bay as now occurs?

A. I think the raw sewage discharged into Newark Bay is a bad thing and may do a great deal of injury, but purified as is proposed here I do not think the purified discharge will do any harm.

Q. Have you any special knowledge of the subject of trade wastes either as discharged from New York sewers or into the Passaic River?

A. No sir.

Q. Do you have any knowledge, casual or otherwise, of the discharge of trade wastes into New York Bay from the City of New York?

A. No sir.

Cross-examination by Dr. O'Sullivan:

Q. You did not graduate from Harvard, did you, Mr. Greene?
A. No sir.
Q. Did you graduate from any educational institution?
A. The ordinary high school.
Q. And you took no degree in civil engineering?
3554 A. No sir.
Q. And no degree in chemistry?
A. No sir.
Q. And no degree in either bacteriology or biology?
A. No sir.
Q. What year were you a member of the dock department of New York City?
A. 1875. I was not a member of the dock department, I was an employee, engineer in chief if you please, from 1875 to 1898.
Q. I direct your attention to page 4 of defendants' exhibit No. 1.
A. Yes sir.
Q. I refer to the last paragraph and begin at the second sentence where it says "For many years he was a member of the dock department of New York City." Was that correct or not?
A. I was an employee of the dock department, but I was not a member of the Board governing the department, the department of docks consisted of three men, they constituted the board in my notion. I did not write that, and I don't know who did.
Q. Is that correct or incorrect?
A. I have endeavored to explain it, sir, that I was an employee of the department of docks, as engineer in chief, that was my title.
Q. What did you understand in 1875 as the dock department of New York City?
A. The board of the commissioners governing the affairs of the department.
Q. Were you a member of that board?
A. No sir.
Q. So that is a misstatement, is it not, that you were for
3555 many years a member of the dock department of New York City?
A. As a member of the board the department, it is a mistake. As an engineer of the department, if that constitutes a membership, in some people's opinion, why it is correct.
Q. *Who* do you regard it?
A. I consider that I was an employee of the department, sir.
Q. Directing your attention to page 8 of defendants' exhibit No. 1, from which you read the figures that you gave, which you say were taken from the United States Coast Survey in 1886—is that correct?
A. Yes sir.
Q. Do you know whether those figures have since been corrected?
A. I do not.
Q. Taking all the figures that you have given us with regard to the ebb and flow volume, they related to waters above the narrows, is that correct?
A. I read some at the narrows, I think.

Q. Do you know where the cross sections were taken to measure that volume at the narrows?

A. No sir.

Q. What do you understand by the narrows?

A. The stretch between the upper and lower bay between a certain distance on Staten Island and between a certain distance on Long Island.

Q. Do you know the length of the narrows?

A. I do not remember, no.

Q. Do you know the width?

A. No.

Q. Do you know the depth?

A. Approximately one hundred feet or something of that kind.

Q. Do you know where that cross section was taken which
3556 you read as "Narrows," ebb and flood"?

A. No sir.

Q. Do you know whether it was taken on the New York upper bay side of the narrows, or the New York lower bay side of the narrows?

A. No sir.

Q. I ask you if all those cross sections which you read were not taken above the narrows?

A. I do not know sir.

Q. Were those the most favorable sections which you have taken to the argument which you have undertaken to support with them?

A. I do not know whether there are any more favorable locations or cross sections to be taken or not.

Q. Are you sure that you did not embody in your report that those sections were selected as the best. Please answer without consulting your report.

Mr. Riker: No, he can consult the exhibit, you cannot catch him that way.

Q. Can you answer that question without consulting the report?

Mr. Riker: You do not have to.

Q. I ask you if you can.

A. May I have the question repeated.

Q. (Question read as follows: "Are you sure that you did not embody in your report that those locations were selected as the best?")

A. Now you wish to know whether I can answer that question without looking at the book or not?

Q. Yes.

A. No sir, not certainly, I do not recollect exactly.

Q. Do you consider that the waters above the Narrows should be taken into any estimate of lines of dilution for the sewage
3557 proposed to be discharged at Robbins Reef?

A. Water above?

Q. Above the Narrows.

A. Yes, sir.

Q. I direct your attention to the third paragraph on page 9 of defendants' exhibit No. 1:

"As the discharge or outfall of the sewage is to be on the westerly side of the main channel, and as there will be no sufficient force to push the sewage across the current of the channel, it is not proper to consider for localities above the Narrows this total volume of the water passing in and out of the upper harbor, as that available for diluting or dissipating the sewage."

Do you recall having embodied that as part of the report you made?

A. Yes, sir.

Q. And it was correct, based upon the premises that you were making your report on, was it?

A. Yes sir.

Q. Do you regard sewage as lighter or heavier than the water it would be discharged into in New York Bay?

A. It may be or it may not be.

Q. Do you recall what opinion you expressed on that in your report of 1903?

A. Yes.

Q. Which did you conclude it was then?

A. Lighter.

Q. Do you still regard it as lighter?

A. As a general proposition, yes, but it may carry some salt or something in solution, mechanical solution in it, which will make it not so; but as a general proposition I adhere to what I said then.

Q. Do you recall then describing the sewage which was
3558 contemplated to be brought in the Passaic Valley trunk sewer?

A. Yes sir.

Q. Has its character changed in your estimation since 1903?

A. I think it is probably more purified as now proposed than it was then.

Q. Would that make it lighter or heavier?

A. It would probably make it lighter, but possibly, through carrying something in solution, it might make it heavier.

Q. What do you contemplate it would be likely to carry in solution that would make it heavier?

A. Some organic matter that is heavy might be there.

Q. I call your attention, Mr. Greene, to the last line of page 10, of defendants' exhibit No. 1, and the succeeding lines forming that paragraph:

"In addition to simple dilution by discharge into the large volume of current, I consider the plan of discharging the sewage at a depth of forty feet below the surface, of value, because the sewage being fresh water and lighter than salt water has a tendency to rise, and in rising it will spread and be diffused, thereby increasing the dilution and dissipation of the sewage."

Q. Do you recall embodying that in your report?

A. Yes sir.

Q. Do you now think that the sewage which you then described as

likely to rise would be so heavy in the present instance as not likely to rise?

A. No sir.

Q. Are your estimates for dilution entirely based on the Coast Survey Report for 1886?

A. Yes, sir.

Q. Do you know what the tidal prism in New York Harbor is now?

A. The tidal prism in New York Harbor is the difference
3559 between high and low water mark bounded by the borders of the Harbor.

Q. What is its volume in cubic feet or cubic yards?

A. I do not recollect.

Q. Have you yourself ever made any effort to determine what the volume of the tidal prism in New York upper bay is?

A. I think so, but I do not recollect it.

Q. If this sewage which you have described here as light and with a strong tendency to rise, rises to the surface, would it not be visible?

A. If it was not diluted before it got there so that it would not be noticed by the senses it might be visible.

Q. How deep down is the under run?

A. I do not know.

Q. Do you know anything about the phenomena of the under-run in upper New York Bay?

A. Very little.

Q. How do you know this sewage would rise or be carried by the under run?

A. It is a matter of opinion.

Q. Is it a matter of opinion whether there is an under run or not in New York upper bay?

A. I think that has been proved.

Q. What do you understand by the under run?

A. The movement of the salt water underneath the surface water which is brackish or lighter.

Q. How deep is the channel at that point, at Robbins Reef?

A. About seventy feet.

Q. How high up does the under run come?

A. I do not know.

Q. So that the under current would take matters discharged into it north while the ebb was going south, is not that a fact?

A. I think so.

3560 Q. Do you know whether it is or not?

A. I do not know.

Q. So that this sewage discharged into the under run would be taken in the region of the Hudson or East River either on an ebb or flood tide, would it not?

A. It might.

Q. When were you retained in this case?

A. This one here now?

Q. For the testimony you have given now?

A. I think about the latter part of December, the 28th or something like that.

Q. Six or seven weeks ago?

A. I think so.

Q. Have you made any tour of inspection of New York Harbor's water since then.

A. No sir.

Q. Have you made an inspection of New York Harbor waters since your connection with the Dock Department?

A. Oh, yes.

Q. When?

A. At the time I made this report I looked about a good deal.

Q. Since 1903?

A. Nothing direct and special since 1903.

Q. You mentioned Mr. Herring's report in 1903; Mr. Herring was the parent of this trunk sewer scheme, was he not?

A. I think so.

Q. Do you know what his present attitude is toward the feasibility and efficiency of that trunk sewer project?

Mr. Riker: Objected to on the ground that it is immaterial, irrelevant and impertinent.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not.

3561 Q. In determining questions of dilution do you take into consideration the question of whether or not the water that is to act as the dilutent is already heavily polluted or not?

A. Yes sir.

Q. Did you take that into consideration in New York Bay in 1903?

A. Yes sir.

Q. How does New York's upper bay present condition as to pollution, compared with the condition that it was in in 1903?

A. I do not know that it has changed substantially.

Q. How much has New York City increased in population since 1903?

A. I do not know.

Q. Do sewage discharges bear any relation to increase in population?

A. Probably yes, I suppose so.

Q. Can you state more affirmatively, one way or the other?

A. Why I think so, decidedly.

Q. Would it surprise you if New York's upper bay was in a similar condition to what it was in 1903 and yet the population has increased over four hundred thousand?

A. If you are going to make a chemical analysis I would expect there would be some difference; if you simply depend on the ordinary sense of sight and smell I doubt if there is any.

Q. Have you known of any oxygen determinations for the upper bay?

A. No sir.

Q. Do you regard oxygen as a fair measure of the condition of the water as to pollution, or the absence of pollution?

A. Do I?

Q. Yes.

A. No sir.

Q. It would not have any influence on your opinion
3562 whether it had a large or small oxygen content?

A. It might do something of that kind.

Q. Would it materially do it?

A. It might materially, on more information than I have in regard to the function or value of oxygen in the water. As I understand it water will receive but a small amount of oxygen over and above what it naturally has.

Q. What would you place that amount at?

A. I cannot tell you, I am not a chemist.

Q. Five per cent?

A. I would not hazard anything.

Q. Three per cent?

Mr. Riker: He said he would not hazard anything.

Q. Can you give me an approximation?

A. No, sir.

Q. How would you determine whether water was or was not polluted?

A. By inspection.

Q. Simply by the *aleofactory* sense and the sense of sight?

A. Yes, that is all.

Q. Is it possible or probable in your opinion for water to be highly polluted and yet not give off offensive odor?

A. I think it is possible, yes.

Q. In that case how would you determine the presence or absence of pollution?

A. By chemical analysis.

Q. Have you ever conducted any chemical analyses?

A. No, sir. I mean not personally.

Q. What would the chemical analyses be directed towards determining, what fact or condition or element?

A. It might be for some substance carried in solution, or it might be for germs, or something of that kind.

Q. Have you ever seen the effluent from an Imhoff tank?
3563 A. No, sir.

Q. Have you ever seen the effluent from a septic tank?

A. No, sir.

Q. Have you ever seen an effluent from any sewage disposal system?

A. Disposal system?

Q. Yes.

A. Not that I recollect.

Q. Have you ever been in charge of disposal works anywhere?

A. No, sir.

Q. Have you ever had any direction or control over sewage disposal works or sewage purification projects or schemes?

A. No, sir.

Q. What do you mean by visible suspended particles?

A. Sometimes in water, in moving water, there are small particles of—I don't know what, possibly water soaked vegetation, wood or timber or something like that; possibly paper.

Q. They would be visible on the surface of the water would they not?

A. Oh yes.

Q. How would you determine whether or not there were visible suspended particles immediately below the surface of the water, say six inches below the surface of the water?

A. If I wished the information I suppose I would dip up the water and look at it.

Q. Have you ever done that in New York Upper bay?

A. Not for a good while.

Q. What do visible suspended particles that have such origin represent, organic or inorganic matter?

A. I think they represent organic matter.

Q. And highly putrescible?

A. Perhaps.

Q. You said, relative to the deposits, as I understood it, that you would not expect those deposits to be substantial; did I get that right?

3564 A. Substantial, or of substantial value.

Q. I want to be a little more definite on that if I can; what would you consider a substantial deposit, or a deposit of substantial value?

A. One that decreases the depth of water, one that made on the bottom of the bay and decreased the depth of the water to some extent, some substantial value or extent.

Q. To what extent would you expect deposits from a sewage effluent whose results are guaranteed in complainant's exhibit No. 135, just a rough approximate.

A. If that discharge carried with it but one-thousandths part of the total quantity discharged of mineral material that would settle on the bottom eventually, it would make a layer about one-thousandth of an inch think, or three hundred and sixty-five one thousandths of a foot per year. That I do not think would be objectionable to the Secretary of War.

Q. Did you read General Roberts' testimony given in this case?

A. No sir. Oh, I don't know but what I did, I beg pardon, I think I did.

Q. Did you follow his line of computation for the amount of sedimental and deposited matter.

A. Not that I recollect.

Q. What percentage of organic matter in sewage do you regard as sedimentable?

A. As what?

Q. Sedimental, capable of being deposited?

A. I have not made any estimate of it, I have not any definite idea.

Q. The estimate that you did give related to the inorganic matter did it not?

2565 A. Yes, mineral.

Q. Do you think that amount of organic matter would equal in volume the inorganic?

A. That is the general report of works, books on the contents of American sewage.

Q. Do you regard the sewage contemplated to be carried in the Passaic Valley trunk sewer as unusually rich in trade waste?

A. I have not so considered it, no.

Q. What percentage would be trade waste?

A. I do not know.

Q. Do you recognize that the Passaic Valley has a very large number of factories?

A. I have heard so.

Q. Do you know whether there are many there or not, of your own knowledge?

A. No, I do not.

Q. Do you know what the character of any of those trade wastes that would be taken by the Passaic Valley trunk sewer, as to their organic contents, is?

A. Not as to absolute knowledge, only hearsay.

Q. Do you know if some of those trade wastes are rich in coloring matter?

A. I suppose so, but I have no absolute knowledge of any trade wastes.

Q. Do you recognize a color form of nuisance, a color nuisance; can color be so objectionable in other words as to become a nuisance?

A. On the surface of the water?

Q. Yes.

A. I should hardly think so.

Q. Have you ever seen the sleek fields in Boston Harbor?

A. Not that I recollect.

2566 Q. Have you ever seen the tar coverings of some of our bodies of water from gas works?

A. Some, yes sir.

Q. Do you regard those as a color nuisance?

A. I do not think they are a nuisance; they did not strike me as objectionable as far as their color was concerned.

Q. Is there any provision in complainants' exhibit No. 135 to remove the coloring matters from these various wastes that are contemplated to be discharged at Robbins Reef?

A. I think there is incidently, but not mentioned directly.

Q. Is coloring matter sedimentable?

A. It may be.

Q. For instance, what coloring matters are sedimentable that you know of?

A. Indigo.

Q. Will indigo precipitate?
A. Sometimes.
Q. And leave any color behind?
A. Not wholly, it leaves some generally.
Q. What other coloring matters are sedimentable?
A. I do not think of any other, I do not recall any other.
Q. Are colloidal matters larger in volume in septic sewgae than in fresh sewage?
A. Is what?
Q. Colloidal matters?
A. Oh, I don't know, I don't know, sir.
Q. Do you know what colloidal matters are?
A. Yes sir.
Q. What are they?
A. Oh something like a jelly,—jelly form.
Q. Is that your best description of colloidal matters?
A. Yes sir.
Q. How does a colloidal matter in suspension differ from
3567 a true solution?
A. I don't know.
Q. Which is the more putrescible?
A. I don't know.
Q. Which will consume the larger amount of oxygen from the waters into which they are discharged?
A. I don't know.
Q. Do you know of any provision made in the stipulation for the removal of either organic matters in solution or colloidal matters?
A. I think that when it passes through these tanks full of stone both those matters would be collected, taken from the water; but I have not any accurate knowledge in regard to sewage treatment.
Q. Does screening remove organic matter in solution?
A. Screens?
Q. Screens.
A. They might.
Q. Organic matter in solution?
A. Oh, in solution? No, I suppose not.
Q. Will sedimentation remove organic matter in solution?
A. I think so, but I don't know.
Q. How would you sediment organic matter in solution, how would your deposit it?
A. Let it stand in still water.
Q. And it will deposit?
A. I think so, if it is heavier than water, not otherwise.
Q. Do you believe that pathogenic germs can live for any definite time in sewage?
A. I have not any definite information in regard to pathogenic germs.
Q. Do you know whether or not tubercle bacilli will live for over ten months in putrefying sewage?
3568 A. No sir, I do not.
Q. Do you know how long the bacillus typhosus will live in sewage?

A. I do not.

Q. Is there any provision in complainants' exhibit No. 135 for the removal of these disease bearing germs?

A. I do not know of anything specific, but in general I think there would be some removal of them.

Q. Would it be appreciable in your estimation?

A. I do not know.

Q. What do you mean, Mr. Greene, by exclusion of trade wastes at factories?

A. There are certain substances that ought not to go into the sewer, for instance, what I had in mind was that a brewer at one time poured all his grains into the sewers and as the engineer in chief of the dock department I had to go and dredge them out of the harbor and protest against his being allowed to do it any more, putting them into the sewer.

Q. What provision is there to prevent brewers along the Passaic water shed from discharging their grains into the trunk sewer?

A. I don't know.

Q. There is none as far as you know?

A. I don't know anything about that.

Q. Have you examined the plans and specifications of the Passaic Valley Sewerage Commissioners?

A. No sir.

Q. I did not quite catch what you meant by tanks of stones—I caught the words in reply to some question put to you by Mr. Riker, some matter you alluded to in relation to tanks full of stones, or something like that; that it how I caught it.

A. It shall pass through screens to remove all floating matter "and after passing through such coarse screens shall pass
3569 through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable." I do not exactly know what size they mean here, but I have heard, in some places, of a tank being filled with broken stones and the sewage passed through it, because certain of the matter contained in the sewage adhered to the stones which were afterwards taken out and washed.

Q. And you regarded that, did you not, as a good provision?

A. I think it was, in the account that I read of it, it was commended.

Q. And you find no such provision for the disposal of sewage in the Passaic Valley sewerage process?

A. Not definitely, no sir, not specifically.

Q. Have you studied the sewage disposal scheme for the Newark meadows contemplated by the Passaic Valley Sewerage Commissioners?

Mr. Riker: I did not know there was any for the Newark meadows.

The question is objected to on the ground that it does not appear in the evidence there is any scheme for the sewage of the Newark meadows.

The Commissioner: Note the objection of counsel for the defendants.

A. If I understand your question, sir, I have not.
Q. Where has it been described to you that these sewage disposal works were to be erected?
A. In this stipulation?
Q. Yes, in complainants' exhibit No. 135?
A. In this—I don't know what you call this.

Mr. Riker: That is supposed to be a copy of complainants' exhibit No. 135.
Witness: In complainants' exhibit No. 135?
Q. Yes.
A. Do you wish me to quote that?
3570 Q. I do not think you understood my question.

(Former question read to witness as follows: "Where has it been described to you that these sewage disposal works are to be erected?")

A. At a point at or near the pumping station to be located on the Newark meadows near the Newark Bay.
Q. And the effluent that would be produced through the operation of these disposal works, how was that to be conveyed to New York upper bay?
A. By pipes, pumping.
Q. Did you get a description or did you see plans of those pipes?
A. No sir, I did not see any plans of them, I think some description gave the size of them, that I read some time or other.
Q. Do you know the material that the pipes were to be made of?
A. I think they were to be made of iron or steel, steel I think.
Q. Was it described to you how low, with reference to the waters in Newark Bay, those pipes were to travel?

Mr. Riker: The question is objected to as immaterial and irrelevant.
The Commissioner: Note the objection of counsel for the defendants.

A. Not that I recollect.
Q. I understood you to say that this effluent would not cause any material injury to Newark Bay if discharged into it, am I right.

Mr. Riker: He never said so.
Dr. O'Sullivan: I asked him if he said so.

Witness: No sir, I never said any such thing.

Mr. Riker: I do not think it is fair for counsel to put into the witness' mouth things that he knows he did not say. That
3571 is my objection to the question.
Dr. O'Sullivan: He said it and the record wil lshow he said it.
The Commissioner: Note the objection of counsel for the defendants.

Q. Would this effluent injure the waters of Newark Bay?

A. I have made no study of Newark Bay and know nothing in detail about it, and therefore cannot answer your question.

Q. Can you recall any question being put to you by Mr. Riker as to what influence that effluent would exert if discharged into Newark Bay?

A. Yes, sir, but if you please, I understood that to be the sewage as now discharged, which goes down through Newark Bay and out into the Kill von Kull; not anything that you call an effluent from these works.

Q. Would that effluent differ in any particular no matter where it was discharged; would the point of discharge influence the character of the effluent?

Mr. Riker: The question is objected to as immaterial, incompetent and irrelevant and answering itself.

The Commissioner: Note the objection of counsel for the defendants.

A. I suppose that the character of the effluent as you call it would be the same, but it might be changed very much by the place, the locality, where it was discharged.

Q. The effluent whose results are guaranteed or stipulated for in complainants' exhibit No. 135, how would that be influenced, changed or altered by discharge either in New York Bay or in Newark Bay?

Mr. Riker: The question is objected to on the ground that the effluent is not described in the stipulation, but it is guaranteed that a discharge into New York Bay of the Passaic Valley sewage
3572 will produce certain results there.

The Commissioner: Note the objection of counsel for the defendants.

A. In Newark Bay I do not know, because I do not know Newark Bay and have not studied it; in New York Bay there is a large volume of water into which it would be discharged, which would dilute it.

Q. How does this volume of water in Newark Bay compare with the volume of water in New York Bay?

A. I do not know, sir.

Q. Does the character of water in Newark Bay, either as to its salinity or otherwise, differ from the water in New York upper bay?

A. I do not know sir.

Q. Then what features, or factors, in the waters of Newark Bay would you need to know of in order to determine whether or not the effluent would be different if discharged into that body of water from what it would be if discharged into New York upper bay?

A. One of them would be the volume.

Q. The volume of what?

A. Of water in Newark Bay passing by the point of discharge of the sewage.

Q. If this effluent in its guaranteed results will have no visible

suspended particles, or the other matters stipulated for, of what effect would greater dilution be?

Mr. Riker: Objected to on the ground that there is no effluent guaranteed or provided for, but that the only discharge spoken of is as being the discharge from the Passaic Valley sewer into New York Bay.

The Commissioner: Note the objection of counsel for the defendants.

3573 A. I do not know whether I understand that question. If it did have some floating particles before it was diluted, there might be so many of them—so dense—that they could be seen, but in dilution they would be so separated they would not be seen, it would be too diluted, in case it were there.

Q. Any other effect?

—. ——.

Q. What percentage of matter would be removed from the sewage carried in the trunk sewer project, by the sewage disposal works contemplated in complainants' exhibit No. 135?

A. I don't know.

Q. What percentage of solid or organic or inorganic matter would be carried in the effluent discharged from the sewage disposal works?

A. I don't know sir.

Q. How do you know then that the matters discharged from the sewage disposal works would need dilution?

A. I assume that they do need dilution, that dilution is advisable because the discharge from the sewer is not absolutely pure, or not as pure as it can be made by dilution.

Q. How does dilution purify a septic effluent.

A. In the same way that it would not be so strong if mixed with a larger amount of fluid.

Q. And that is the only benefit you would get from dilution?

A. Yes, the only one I think of.

Q. Have you ever crossed Newark Bay in any form of craft on the water?

A. Not that I recollect.

Q. Can you tell me where the most advantageous place in Newark Bay would be for the discharge of an effluent from the sewage disposal works described in complainants' exhibit No. 135?

Mr. Riker: The question is objected to as irrelevant, immaterial and impertinent.

3574 The Commissioner: Note the objection of counsel for the defendants.

A. No sir.

Q. Have you read the testimony of any of the gentlemen described by Mr. Gray in his testimony, who offered their evidence in this case?

A. I do not recollect reading the testimony of anybody in this case excepting General Roberts, I think he is the only one.

Q. What data was submitted to you before asking your opinion today in regard to this litigation.

A. Data? I did not have data, that I would call data. Perhaps I do not understand your meaning of that term.

Q. Did you read any other testimony given in the case except that of General Roberts?

A. Not that I know of.

Q. Did you examine the plans and specifications of the Passaic Valley Sewerage Commissioners?

A. No sir.

Q. For this trunk sewer?

A. No sir.

Q. Did you read any of the reports of the Passaic Valley Sewerage Commissioners other than the one which has been offered in evidence here.

A. Mr. Herring's report I read, if that is what you mean.

Q. And that is included in defendants' exhibit No. 1, is it not?

A. I think not, Mr. Herring's report has not, so far as I know been marked as an exhibit yet.

Q. What report do you refer to now?

A. The annual report of the Passaic Valley Sewerage Commissioners to the Legislature, Session of 1903, on page 21 of that begins a report of Mr. Herring—I think his first name is Rudolph, but I am not clear about that—yes, Rudolph Herring, that is right.

3575 Q. Have you read any other report besides the report of Mr. Herring in 1903, and the report to which you contributed material and which is now in evidence as defendants' exhibit No. 1?

A. Not that I recollect, now.

Q. So that the facts, plans, reports and other matters, with the exception of General Roberts' testimony, have all been before 1903, that you have consulted and read, is that right?

A. Yes sir.

Q. How was that effluent to be sent to New York upper bay from the sewage disposal works on the Newark meadows?

A. How was it to be sent?

Q. Yes.

A. Pumped, I understood.

Q. And pumped after the sedimentation and screening and other processes that you have described?

A. Yes sir, I understand so.

Q. Have you made any inspection of the Passaic River within the seven weeks or so since you have been retained in this case?

A. No sir.

Q. Nor of Newark Bay?

A. No sir.

Q. Nor of New York upper bay?

A. No sir, nothing special.

Redirect examination by Mr. Riker:

Q. You have had before you the substance of, or a duplicate of complainants' exhibit No. 135? Have you?

A. Yes sir.

Q. And you were asked to testify on the results of a discharge of sewage producing the guaranteed results?

A. Yes sir.

Q. If you were going to determine whether there were visible suspended particles in water would you do it in any other way than by looking at it?

3576 A. No, I think not.

Q. So that the only way you can tell whether those things are visible or not is by looking at them?

A. I think so.

Q. You testified that as to water you would determine its purity by the senses and not by chemical examination. Did you intend that to apply to potable water or to waters of the harbor?

A. Oh, to waters of a harbor.

Q. If you were trying to determine whether water was fit to drink or not would you get at that in some other way?

A. Some other way, yes sir.

Q. Are the waters of New York Bay potable waters or are they not in your judgment?

A. They are not in my judgment.

Recross-examination by Dr. O'Sullivan:

Q. Can they be made potable?

A. Potable water can be made from them, sir by distillation.

Q. Would it be advisable to add to the sewage disposal scheme those stones that you described in a tank?

A. I don't know, sir, I don't know enough about sewage disposal or purification to say whether it would or not.

Q. You have never had any direct experience in sewage purification?

A. No sir; I referred to that because I had seen it recommended in some writing.

Q. Have you made any calculation to determine how much the tax payers of the Passaic Valley would be saved if the sewage was discharged into Newark Bay instead of into New York upper bay?

Mr. Riker: Objected to as immaterial, irrelevant and impertinent.

The Commissioner: Note the objection of counsel for the defendants.

3577 A. No sir.

By Mr. Riker:

Q. You made an estimate of the deposit of solid matter on the floor of New York Bay upon a certain assumption, did you not?

A. Yes sir.

Q. Did you make any estimate of the amount that would actually be deposited from the discharge from the Passaic Valley sewer?

Dr. O'Sullivan: Objected to as incompetent.

The Commissioner: Note the objection of counsel for the complainant.

A. No sir, I made that on that assumption only.

By Dr. O'Sullivan:

Q. Is the reason for not making an actual computation that there is no actual discharge of sewage now at Robbins Reef from the Passaic Valley sewer?

A. Oh, no sir. The reason is because I have no other sufficient data. The point that I knew of, one one-thousandth of solid matter from sewage, is derived from an estimate of people who are considered experts, and I assumed that it was correct and used it in that way.

Q. And that referred to inorganic matter?

A. Yes sir, mineral.

Q. And you made no computation of the deposits from organic matter?

A. No sir.

Q. Nor from colloidal matter?

A. No sir.

The further taking of testimony on the part of the defendants was adjourned to Thursday, February 13th, 1913, at the office of Messrs. Riker & Riker, Newark, N. J.

3578 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,

vs.

THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker and Riker, Newark, N. J., Thursday, February 13th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esquire, Attorney General of the State of New York;

William A. McQuaid, Esq., Deputy Attorney General;

Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants;

Edmund Wilson, Esq., Attorney General of the State of New Jersey;

Robert H. McCarter, Esq., of counsel for the State of New Jersey;

Adrian Riker, Esq., of counsel for the Passaic Valley Sewerage Commissioners, Defendants.

GEORGE A. JOHNSON, a witness on behalf of defendants, being duly sworn by the Commissioner testified as follows:

3579 Direct examination by Mr. Riker:

Q. Where do you live?

A. Montclair, N. J.

Q. What is your profession?

A. I am a consulting engineer and a sanitary expert.

Q. How long have you been engaged in that profession?

A. For the past 17 years I have been engaged on matters relating to the purification of water and the disposal of sewage.

Q. Where have you been practicing your profession?

A. My experience in this line of work began in 1895 at Louisville, Kentucky, where I was a member of the staff of the Louisville Water Company which was at that time making investigations into the feasibility of purifying the Ohio River water by mechanical filtration. At that place I occupied successively the positions of inspector and assistant bacteriologist. On leaving Louisville I became assistant bacteriologist to the Commissioners of Water Works of Cincinnati, Ohio, where similar studies were inaugerated in the early part of 1899. Leaving Cincinnati I took up work in connection with the filtration of water at York, Pennsylvania, Norfolk, Virginia and elsewhere. I then became assistant engineer to George W. Fuller, Consulting Engineer, who had offices at 220 Broadway, New York City. During the year 1900 I was Associate Director of a special city lar-b-atory of the city of St. Louis, making investigations into the effects of the Chicago Drainage Canal upon the water supply of that City. Following that engagement I was engaged at Philadelphia under Mr. Rudolph Herring, Consulting Engineer of New York, on actual studies relating to the filtration of the water supply of Philadelphia.

My next engagement was in charge of the operation of a 3580 mechanical filter plant located at Little Falls, New Jersey. I then became principal assistant engineer in the department of chemistry and biology of the commission on additional water supply for New York City and during the year 1903 made a sanitary survey of the Hudson River Water Shed. In the years 1904-5 I was engineer in charge of the testing station at Columbus, Ohio, where there were made, under me, exhaustive tests of the various methods of purifying the water supply, and of purifying the sewage, of that city. The results of my investigations at Columbus, were published as a city document in 1905. The year 1906 I spent abroad investigating municipal water supply works in Japan, China, the *Straight* Settlements, Ceylon, India, Egypt, France, Germany and England. Returning I became assistant engineer to Messrs. Herring and Fuller, Consulting Engineers of New York, and in 1908 was made a member of that firm, continuing as such until October, 1910, when I formed a partnership with William B. Fuller, with offices at 150 Nassau Street, New York City. I have been engaged during my professional career on a large number of water supply, sewerage and sewage disposal projects; among others of the last named might be mentioned Columbus, Ohio, Plainfield, New Jersey, Garwood, New Jersey, Chicago, Illinois, Vincennes, Indiana and numerous others. My more important engagements during the past year have been Consulting Engineer to the Bureau of Water Supply of Pittsburgh, Consulting Engineer and a member of the Board of Experts of the Department of Water

Supply, Gas and Electricity of New York City, in connection with the problem of the filtration of the Croton supply; Consulting Engineer to the New York State Conservation Commission, in-
3581 vestigating the pollution of shell fish in New York waters.

In addition to these engagements I have designed, or there has been designed under my direction, sewerage works at Glen Cove Long Island, Wildwood, New Jersey and elsewhere, and water purification works for Trenton, New Jersey and elsewhere.

Q. What preliminary education and training did you have before beginning your actual profession?

A. So far as preparing myself technically for the active prosecutions of the profession of Consulting Engineer on water supply, sewerage and sewage disposal, I had none; I have acquired such knowledge as I possess by successively working up through various stages leading to this untimate end.

Q. What special connection have you had with the Passaic Valley Sewage project?

A. In 1907 when I was connected with the firm of Herring and Fuller, that firm was acting as consulting engineers to the Passaic Valley Sewerage Commissioners and to me was given the task of solving the problem of the disposal of the sewage of the district. The design was placed in charge of my present partner, William B. Fuller. I actively prosecuted this investigation during the year 1907, paying particular attention to questions involving the probable composition of the Passaic Valley Sewage, including an investigation into the trade wastes of the district, their probable volume and composition and the effect which they would likely have on composition of the sewage as discharged.

Q. Do I understand you had charge of that branch of investigation of the matter of trade wastes?

A. I did.

Q. You had assistants under you, did you not?

A. I did.

3582 Q. Have you familiarized yourself with the plans of the Passaic Valley Sewerage Commissioners with reference to the treatment of the Sewage of the district?

A. I have.

Q. How recently have you made investigation of that matter?

A. My last investigation was made February 10th, which was last Monday.

Q. I show you Complainants' Exhibit No. 135 in this case and ask you to look at it and see whether you have familiarized yourself with the contents of that exhibit—stipulation?

A. I have read this stipulation prior to this time and consider that I am familiar with it.

Q. Returning to the plans of the Passaic Valley Sewerage Commissioners with reference to this sewer, do you know what percentage of the trade wastes of the district are planned to be accom-odated by the sewer?

A. It is my understanding that when the full Passaic Valley

project shall have been completed the amount of trade wastes which the discharge from the sewer will then contain will be not more than ten per cent of the total volume so discharged.

Q. Have you made any investigations to di-cover data as to the trade wastes of the greater City of New York?

A. I attempted to gather data on this point but was unable to find any complete records of a study of the trade wastes of New York City. I have, however, compiled several tables from volume 9 of the 13th (1910) census of the United States which show the industry in New York City, and the different boroughs, having trade wastes. These are tabulated by first giving the character of the industry, the number of the establishments, total persons en-
3583 gaged, cost of the materials and the value of the material, added to by the manufacturer thereof. I have compiled similar data for the three largest contributors to the Passaic Valley Trunk Sewer, namely, Paterson, Passaic and Newark. It is possible from the data to gain some light on the relative amount of trade wastes discharged into New York waters from New York City, and to be anticipated in the discharge of the Passaic Valley Trunk Sewer.

Q. Do you know whether the trade wastes of New York City are discharged directly into the waters of New York Bay, into the Hudson River and the East River?

A. That is my understanding, yes, sir.

Q. Have you examined the reports of the Metropolitan Sewerage Commissioners in determining whether they have made any study of their own trade wastes?

A. I have for a number of years past read with interest the reports of the Metropolitan Sewerage Commission but I do not now recall that I have ever seen any precise reference to trade wastes in New York City giving details of importance; the matter is only referred to in a general way.

Q. Have you happened to observe whether they have given considerable attention to the trade wastes of the Passaic Valley district?

A. I think that they have yes, sir.

Q. Turning again to your tabulation, have you it in such form that you can separate it from other memoranda or so that I can offer it in evidence?

A. I think I have. I hand you six tables showing the data above referred to for New York City, Manhattan and the Bronx, Borough of Brooklyn and for the cities of Paterson, Passaic and Newark, all compiled from volume 9 of the 13th Census of the United States.

3584 Q. Compiled by whom?

A. Compiled by me.

Mr. Riker: I offer in evidence nine sheets embodying the matters that have been mentioned by the witness and ask that they be marked Defendants' exhibit No. 2 in this case.

By Dr. O'Sullivan:

Q. What was the source of knowledge you sought in making these tabulations or these tables?

A. Lacking information of a more definite and desirable character I attempted to show by comparison of the number of establishments, number of persons engaged in those establishments and the cost and value of material produced by those establishments, how the individual side of this problem in the Passaic Valley district compared with the industrial side of *of* the sewage of New York City.

Q. I think you misunderstood my question, Mr. Johnson, I am asking for the source of the information which you have given here in tabulated form?

A. That is taken from the 13th Census of the United States.

Q. And from no other source?

A. No, sir.

Q. Does it represent any work done by you, other than the arrangement here?

A. No, sir.

Q. And the data comes from the Federal Census of 1910?

A. Precisely.

Dr. O'Sullivan: I object to this exhibit being received or marked in evidence on the ground that it represents no original work done by the witness.

3585 The Commissioner: Note the objection of counsel for the complainants.

(Marked Defendants' exhibit No. 2)

Further direct examination by Mr. Riker:

Q. Taking up defendants' exhibit No. 2 in this case, in a general way, does the character of the industrial establishment and the trade wastes to be expected from them in the greater city of New York differ materially from those of the Passaic Valley district?

A. In my opinion it does not.

Q. In your examination of the actual plans of the Commissioners for the construction of the Passaic Valley Sewerage Commissioners' Purification Plant do you or do you not find that those plans embody the devices and processes which are specified in the stipulation, complainants' exhibit No. 135?

A. From my examination of those plans, and especially on February 10, 1913, I am of the opinion that the plans do anticipate and comply with the terms of the stipulation referred to.

Q. In your opinion as an expert if the sewage of the Passaic Valley district as discharged into New York Bay shall have been so treated that there will be an absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage, that there will be absence of deposits objectionable to the Secretary of War of the United States in the New York Bay coming from Passaic Valley sewage, that there will be absence in the New York Bay and in its vicinity of odors due to the putrification of organic matters

contained in the Passaic Valley sewage thus discharged, that there will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley
3586 sewage at the dispersion area or elsewhere, that there will be no injury to the public health which will be occasioned by the discharge from the said sewer into the bay of New York in the manner proposed and no public or private nuisance will be created thereby, and that there will be absence of injurious effects from said sewage discharged upon the property of the United States situated in the Harbor of New York and that there will be absence of reduction in the dissolved oxygen contents of the waters of New York Bay resulting from the discharge of Passaic Valley sewage to such an extent as to interfere with major fish life, there will be any nuisance created in New York Bay by such discharge?

A. In my opinion there will not.

Q. As a supplemental along those lines I would ask you if there is no public or private nuisance created by such discharge in your opinion can there be any such private or public nuisance created by it.

Dr. O'Sullivan: The question is objected to on the ground of ambiguity.

The Commissioner: Note the objection of counsel for complainants.

Mr. Riker: Counsel for the defendants says that it is his understanding that this suit is based upon a threatened nuisance to be created by this discharge and that this question is directed to the stipulation as providing expressly against any nuisance to be created.

(The question was then read by the stenographer.)

Dr. O'Sullivan: The question is again objected to on the ground that it is argumentative, and not fairly a question.

The Commissioner: Note the objection of counsel for the complainant.

3587 A. No.

Q. Mr. Johnson, in your opinion as an expert, if the sewage of the Passaic Valley district shall be treated in the manner described specifically in the stipulation, complainants' exhibit No. 135 in this case, will the result guaranteed and which I have read to you in my next to the last preceding question in your opinion be produced in the waters of New York Bay?

Dr. O'Sullivan: Objected to on the ground that there is no evidence in this case as to the sewage disposal method to be employed. Secondly, on the ground that this witness has disclosed no familiarity with or knowledge of the proposed system of sewage disposal.

The Commissioner: Note the objection of counsel for the complainants.

A. I believe that it will.

Q. Are you familiar with the present conditions of the Passaic River from the Great Falls at Paterson to the Newark Bay and of the Newark Bay to the Kill von Kull?

A. I am and have been for a number of years.

Q. Taking the Passaic River from its mouth at Newark Bay up to the upper boundary of the city of Newark, can you describe from a sanitary point of view the condition of the waters of the river at the present time?

A. During my quite frequent trips up the Passaic River during the past ten years I have had occasion both in summer and winter to observe the unsightly, unsanitary and offensive conditions of this stream. The facts are clear, that the stream is nothing more or less, nor has it been for years back, than an elongated septic tank. Matters discharged into this river from the various sources along its course, have resulted in the deposits of organic sewage
3588 matters which have been acted upon bacterially and being so acted upon putrifactive conditions have been set up and since these deposits are constantly being added to, such offensive putrefactive conditions have been constantly maintained. The river is black in appearance, foul-smelling and virtually devoid of oxygen, within the limit you have mentioned.

Q. What in your opinion has been the cause for the condition which you have described?

A. Nothing more or less than that the crude sewage matters entering the stream have overtaxed its sewage digesting powers and the velocity of the stream has not been sufficiently great to prevent the deposit of organic matters which, when undergoing bacterial decomposition and putrefaction, become blackened, give off foul odors and produce compounds *which* an active affinity for oxygen.

Q. Have you attempted in any way to determine the average length of time during which sewage matter discharged into the Passaic River remains in the river before it reaches Newark Bay?

A. I have not made such studies.

Q. Do you know whether they remain for a considerable time on the average?

A. Do you refer to sewage matters or——

Q. Yes?

A. There seems to be little doubt but that these sewage matters remain for the most part almost indefinitely.

Q. The waters of the river as discharged into Newark Bay, are they or are they not properly described as septic?

A. They certainly are properly described as septic—and then some.

3589 Q. What do you mean when you term the water septic, what is that condition, the septic condition that you refer to?

A. When the organic matters in the sewage are acted upon by bacterial life the first result is a reorganization of those compounds and until the oxygen in the sewage is practically used up, this is generally termed decomposition; after the oxygen has been used up it is generally termed putrifaction. Septic conditions therefore are those in which putrifactive agencies are present.

Q. As applied to sewage, do you make a distinction between fresh and stale?

A. Yes sir.

Q. At what point does fresh sewage become stale?

A. Practically at the point where the dissolved oxygen is all used up.

Q. Is that or it it not the point which the sewage begins to be septic?

A. It is generally so considered.

Q. Then generally speaking, is there any distinction between stale sewage and septic sewage?

A. Yes sir, there is.

Q. What is that distinction.

A. Stale sewage if it remained stale and did not enter the putrifactive stage, would probably never create serious offense, but as it enters the putrifactive stage compounds are for- which rapidly use up oxygen in the waters into which such septic sewage is discharged and furthermore offensive odors are given off, and other undesirable features accompany the state of putrifaction.

Q. Are there then degrees of septicization; in other words, you spoke of the waters of Newark Bay as being septic, and "then
3590 some." I suppose you meant by that, did you not, that there are degrees?

A. Yes sir, I did. Over-septicization is a thing particularly guarded against in the design and operation of sewage purification works. It should always be guarded against in propositions like this, where sewage is to be discharged into public waters and disposed of by dilution. Organic matters undergoing septicization after passing a certain point, produce large quantities of sulphur compaounds and iron compounds in combination with sulphur, which rapidly deplete the body of water into which they are discharged, of the oxygen it may contain. Therefore the more septic, within certain limits, sewage may become the more difficult it is to properly dispose of it either by artificial methods of purification or by natural dilution and dispersion.

Q. Returning to the waters of the Passaic River, can you trace their progress from their entrance into Newark Bay—where do they go?

A. It is very clear to me from the data which have been compiled particularly by the Metropolitan Sewerage Commission, that the waters of the Passaic River, or a large part of them, pass out into New York Bay through the Kill von Kull.

Q. What effect on the waters of New York Bay does the discharge of waters from the Passaic River have, with reference to their purity?

A. In considering points along this line I made it a point to look up precise data recorded by the Metropolitan Sewerage Commission in its report of 1912. I there find that the average dissolved oxygen contents of the waters of Kill von Kull on the ebb and flood tide, was, in the year 1911, 74 and 76 per cent respectively. This indicates that the discharge of the Kill von Kull, polluted by the water of the Passaic River is in much better condition to be used as a digestive agent for sewage than the waters of the Hudson
3591 River or the East River at the Battery, where the dissolved oxygen contents of these rivers is much lower.

Q. What in your opinion, Mr. Johnson, will be the effect of the discharge of the sewage of the Passaic Valley district as proposed by the Passaic Valley Sewerage Commissioners upon the waters of Upper New York Bay as compared with the result of the present discharge of the Passaic River waters through Newark Bay and the Kill von Kull in to the same waters?

Dr. O'Sullivan: The question is objected to on the ground that there is no evidence of record which *which* disclose the fact whether or not this witness does or does not know what form the proposed discharge will be in as to its condition of purification or as to what method would be employed in the purification.

The Commissioner: Note the objection of counsel for the complainant.

A. I have made a study of the probable composition of the sewage of the Passaic Valley district and have ascertained the facts that the average velocity of flow of the sewage in the Trunk sewer will be approximately three feet per second. With these premises and with the further information I secured in 1907 on the composition of various sewers discharging at present into the Passaic River but which in the future will discharge into the Trunk Sewer, referring in this particular to the amounts of dissolved oxygen which these discharges contain, I am of the opinion that, as received at the treatment works in Newark, the sewage will normally not be septic, and at no time more than slightly so, if in fact at any time it is. The treatment giving the sewage at the proposed works near, Newark, will in my opinion be sufficient to remove objectionable suspended matters to such an extent that, as discharged at the
3592 dispersion area near Robbins Reef Light, the sewage of the Completed Passaic Valley District project will not be so offensive or deleterious to the waters of Upper New York Bay as would be the case if these sewage matters were obliged to find thir way into New York Bay by way of the Passaic River and Kill von Kull as is the case at present.

Q. Have you any knowledge of the method of discharge of sewage from the greater City of New York into the Hudson and East Rivers and Upper New York Bay?

A. I have, yes sir.

Q. How is that sewage discharged?

A. All of the sewage of New York City is discharged, through several hundred outlets at or near the bulkhead line. In some cases conditims about the shore have become so offensive that the sewers have been carried out to the pierhead line, and this is all. This condition not only holds true of New York City as referring to the Hudson River, New York Bay and East River, and its tributaries, but also as to Jamaica Bay where the sewage is all discharged at the shore line.

Q. For the greatest part is it or is it not untreated and crude?

A. It is practically all untreated and in its crude state.

Q. Mr. Johnson, from the point of view of your profession of sanitary engineer what feature of the discharge of the sewage of New

York as it is at present conducted seems to be the most objectionable?

A. Undoubtedly the most objectionable feature associated with the present method of dis*cah*rge of the sewage of New York City is the fact that it is discharged in an untreated state, contains organic and mineral suspended matters, of which the former
3593 only are important so far as creating a nuisance, and because of the fact that this discharge takes place near the shore line where the opportunities for complete and satisfactory dispersion throughout the Waters of New York Bay are at a minimum and where the opportunities for heavy deposits of these suspended organic matters are at a maximum. This is true because of the fact that the swiftest currents are found in midstream or in line with the channel; around the shore lines these velocities are low and not sufficiently swift all of the time to keep the heavy suspended matters in suspension. These matters are more than usually large in size, or particles, for the reason that the sewers particularly of Manhattan because of the peculiar shape of the island, are short, the distance of travel of these matters from the point of initial contribution, is short, opportunities for these matters to be broken up in transit in the sewer are slight and therefore these matters come out into the waters of the Bay or the rivers in practically the same condition in which they were deposited, or very slightly broken up. This — not usually the case. In most sewers the solid matters have an opportunity to be broken up into small pieces which require less high velocities to keep them in suspension and prevent their deposit in the bodies of water into which they are discharged.

Q. What is the result of the deposit of this solid matter upon the floor of New York Bay or of any other body of water, from a sanitary point of view I speak now?

A. These matters of necessity, as now deposited by New York City, are for the most part *are* deposited near the shores but, also, over practically the entire harbor bottom. From a sanitary standpoint I can only consider the possible debilitating effect on the human organisms which might be created by such gases as
3594 are given off by the decomposition and putrifaction of these matters. So far as actually effecting the health of the community at the present time, I think that is insignificant so far as vitiating the air which the people of that community breathe.

Q. What then in your opinion is the effect of the deposit of this solid matter upon the floor of the harbor upon the digestive capacity of the waters of Upper New York Bay?

A. The putrifactive agencies which are constantly present and active in these deposits on the harbor bottom set up and maintain an action which produces compounds and gases which are more destructive in the absorption of oxygen from water than would be many times the same volume of crude sewage which had not undergone septicization. The greatest effect of the waters in the harbor is this abnormal absorption of oxygen by these compounds which are constantly undergoing putrifaction on the bottom of the bay.

Q. Has your attention been directed to any determination of

oxygen contents of the waters of the Hudson River at its mouth and of the East River at its mouth?

A. Yes sir.

Q. What is the average as you have had your attention drawn to it, and from what sources is the average obtained?

A. I have personally studied the report of the Metropolitan Sewerage Commission for 1912 complainants' exhibit No. 157, and from the data given in that report have prepared a table which I hand you in which are summarized the data in the Metropolitan Sewerage Commission report above referred to bearing on the oxygen contents of New York's waters.

Q. Taking the map of the Hudson River and assuming that the *the* average oxygen contents is what has been determined in the report, what is that figure?

3595 A. At the mouth of the Hudson River the oxygen contents on both sides is 56 per cent saturation.

Q. And at the mouth of the East River?

A. That is 55 per cent.

Q. Do you or do you not find in those figures a comfirmation of your statement as to the results of the deposit of sludge matters on the floor of the harbor from the sewage of New York City?

A. I do decidedly.

Q. You handed me a blue print containing a table and I understand that you prepared this from the Metropolitan Sewerage Commissioners' 1912 report complainants' exhibit No. 157?

A. Yes sir.

Q. Did you prepare that table yourself?

A. That table was prepared in my office under my direction and was personally checked over by me; I believe it to be a true transcript of the record.

Mr. Riker: I offer that in evidence and ask that it be marked defendants' exhibit No. 3.

By Dr. O'Sullivan:

Q. What does this blueprint that you have just handed to Mr. Riker and which has just been offered in evidence purport to be?

A. That is a table in which are brough- together the data given in a report *in* the Metropolitan Sewage Commissioners for 1912, showing the results of the determinations made by that Commission of the amount of dissolved oxygen in the water of New York Harbor and at other points, throughout the year 1911.

Q. What part did you actually take in the preparation of this tabulation, you yourself personally?

A. Nothing in the tabulation, I checked the table as you
3596 see it from the records read from the Metropolitan report by another man.

Q. Who selected the figures that are the basis of the computation here?

A. I did.

Q. Did you make the computations themselves?

A. No sir.

Dr. O'Sullivan: I object to the marking or the admission in evidence of this document on the ground that it does not represent any work done by this witness.

The Commissioner: Note the objection of counsel for the complainant.

(Marked Defendants' Exhibit No. 3.)

Further direct examination by Mr. Riker:

Q. Did your conclusion as to the fact of a deposit in the form of sludge—you call it sludge don't you?

A. Yes sir.

Q. —on the floor of harbors supported by authority?

A. It is, yes sir.

Q. Will you refer to some authority on that subject?

A. Doctor Adeney.

Q. Who is he?

A. He is an eminent British Sanitarian.

Q. Yes.

A. Doctor Adeney in his report to the Metropolitan Sewerage Commission calls attention to this point——

Q. What report do you refer to?

A. 1912.

3597 Q. Complainants' exhibit No. 157?

A. Yes, sir.

Q. Proceed.

A. He says that the deficiency in dissolved oxygen from which as the Metropolitan Commission has shown the waters of harbor generally suffer at the present time, is chiefly, in the opinion of the writer to be ascribed to sewage solids which have been for some years past, and are, *accummutaling* over the greater part of the harbor and are there forming foul deposits and permanent sources of injury to the waters flowing over them.

Again, on pages 117 and 118 of complainants exhibit No. 157 Doctor Adeney has this to say:—"The harbor waters are quite capable of satisfactorily disposing of the liquid sewage matters from the whole population of greater New York and they will be for many years to come provided that the solid matters in suspension in the sewage be first removed and that the discharge of the liquid matters be strictly limited and control-ed so as not to over pollute any portion of the harbor waters."

Q. Mr. Johnson, have you made any study of the effects of the treatment as it is proposed to be administered to Passaic Valley sewage as defined in the stipulation which is complainants' exhibit No. 135, so far as relates to the question of the deposit of solid matters in Upper New York Bay?

A. Yes sir I have.

Q. What have you concluded from such studies as to the percentage of solids which will be removed by the treatment described by the stipulation in this case?

Dr. O'Sullivan: The question is objected to on the ground that there is no evidence in this case so far disclosing what the method of sewage treatment is proposed to be, nor is there any evi-
3598 dence so far from this witness that he is familiar with such processes as contemplated to be put in use by the Passaic Valley Sewerage Commissioners.

The Commissioner: Note the objection of counsel for the complainant.

Mr. Riker: Counsel for the defendants suggests that the question is directed to the treatment described in the stipulation.

A. From the results of my personal study of the efficiency of sewage purification devices similar to those called for in the stipulation I am of the opinion that the percentage removed of solid matters from the discharge of the Passaic Valley Trunk Sewer will be about 50 percent or more of the total suspended solids contained in the crude sewage as delivered at the treatment works near Newark.

Q. The percentage remaining in the sewage after treatment by the methods described in the stipulation will be of what character so far as specific gravity is concerned?

A. After passing through the various parts of the treatment works for sewage as discharged in my opinion will contain only such particles of suspended matter as would be in a very finely devided state of sub-division, and of a specific gravity sufficiently low to preclude their deposit to any material degree, if at all, on the bottom of New York Harbor, in view of the swiftly moving current therein.

Q. What would be the final disposition of the remaining solids in suspension so far as the waters of New York Bay are concerned?

A. I can conceive of a condition where thee matters will remain in suspension for a practically indefinite period, being ultimately swept out beyond the Narrows and inoffensively and per-
3599 manently dispersed in the sea.

Q. If the treatment which is described and prescribed in the stipulation which is complainants No. 135, should be applied to the sewage of the city of greater New York and that of the shores of the Bay which are within the limits of New Jersey have you attempted to make any determination of the probable capacity of the waters of New York Bay for sewage digestion with reference to the number of the inhabitants that will be served?

A. Yes sir.

Q. What result have you reached along those lines?

A. You are referring now to future possible conditions?

Q. Yes.

A. Studies of the possible capacity of water for digesting sewage have been going on for many years; some twenty-five years ago Mr. Rudolph Herring made such study and came to the conclusion that where the dilution of the sewage was less than one part of sewage to sixteen parts of water objectionable conditions were likely to arise; this is equivalent to two and a half cubic feet per second of water per 1000 people contributing the sewage. He furthermore

states that where this dilution is increased to one to forty-five possibility or probability of offensive conditions being set up are extremely slight. This refers to about seven cubic feet per second of diluting water per 100 population contributing. Mr. Goodnough, Chief Engineer of the State Board of Health of Massachusetts, has also given much attention to this point and sets the limit of dilution at one to twenty-three and one to thirty-six, the safe dilution being somewhere between the two. From such standards as these, which are now quite generally recognized as standards and from
3600 such observation along this line I have made personally I have been able to arrive at certain deductions from which I can answer your question.

I have assumed a flow of dilution water equivalent to five cubic feet per second per thousand population. This appears certainly to be on the safe side.

If the sewage is well mixed with the water adequate dilution in New York Harbor is afforded for the sewage of 18,000,500 people. Furthermore, with such treatment as will be given the Passaic Valley sewage given to the sewage of New York, I believe this population can be doubled, practically speaking, provided every available opportunity to make use of the diluting powers of the waters of the bay is grasped.

Q. Then under the conditions that you assume, that the opportunities are taken advantage of, of dilution, sewage treated in the way the stipulation provides for the Passaic Valley Sewage can be digested in your opinion for a population of from thirty-five to forty million inhabitants.

A. I believe that is generally true, and furthermore I believe it is wise to consider in this connection the absolute impossibility of Metropolitan New York ever reaching such a population.

Q. In taking advantage of the diluting power of New York Bay has the question of the depth of discharge of sewage any relation to that question?

A. It must of necessity have a great deal of significance particularly in this case, where the sewage is proposed to be discharged at a depth of not less than forty feet below the surface of the water. As discharged at that great depth, in the presence of constantly moving tides, tidal currents, the angle of app-roach to the
3601 surface will be materially flattened, and in this way better dispersion of sewage effected.

Q. Has the matter of plurality of discharge points any relation to the dispersion of the sewage?

A. That most assuredly will add to the efficiency of the proposed method of disposal. The discharge of this sewage through multiple outlets, in all there are some one hundred and fifty, spreading out over an area three and a half acres in extent, it is — my opinion bound to produce the desired result, namely, practically complete dispersion of liquid sewage throughout the entire body of moving water.

Q. In this aspect, how do the sewers of the city of New York

comply, as far as you have observed them with the requirements of deep discharge?

A. I have not studied all of the sewers of New York but such of those as I have studied, and I think it is generally true of all of them, discharge practically at the surface and at or near the shore line where opportunity for dispersion afforded in the case of the Passaic Valley project *are* not present. It is about the poorest method of sewage discharge that could be thought of.

Q. It is probably the least expensive, is it not?

A. Yes sir.

Q. Have you made any endeavor to determine the average age of the sewage of the Passaic Valley as it will be delivered at the disposal works, as proposed, on Newark meadows?

A. I have. It is rather difficult to get at this in *practice* terms but it appears clear that the sewage leaving Paterson will arrive at Newark some eight hours after it- initial discharge at the upper source; all this time however it is flowing in a sewer only partly full the current being swift, namely, as before stated, about
3602 three feet per second, lineal velocity, and all along its course it will have the sewage discharged from various laterals, many of which will discharge sewage containing considerable quantities of dissolved oxygen, and considerable ground water which naturally contains dissolved oxygen will also find its way into the sewer. These conditions will not tend to encourage putrefactive conditions in the sewage. There are some trade wastes which discharge into the sewer materials which have a germicidal effect on *on* bacterial life. From such studies as I have made of this phase of the problem, I am of the opinion that these wastes will not materially affect the bacterial contents of the sewage as a whole; But at the time of their discharge their effect may be felt and serve as another agency against the maintenance of putrefactive conditions.

Q. When you say eight hours from Paterson is that the extreme the maximum age, of sewage that is discharged?

A. No sir; it is retained for about one hour under conditions of maximum flow through the tunnel into New York Bay a distance of some five miles more; this would add to the age of the sewage perhaps three hours.

Q. What proportion of the total discharge at the treatment works would be represented by the sewage of Paterson, if you know?

A. From such observations as we made in 1907, I believe the sewage of Paterson represents some twenty per cent of the total flow of the sewer under maximum conditions of discharge.

Q. Where is the origin of the largest part of the sewage that will be discharged at the treatment works?

A. At Newark.

Q. When you mentioned the eight hours was that the average for the whole district, or was that the age of the sewage coming from Paterson?

3603 A. That was the age of the sewage from Paterson, the maximum age. The Sewage from Newark would be less than four hours old at the time of its discharge.

Q. Does the sewage in motion at the rate of three feet per second, lineal velocity, become as readily *a*epticised as sewage at rest?

A. No sir, it does not for the reason that the best way to encourage a septic condition of sewage is to allow it to flow at a velocity sufficiently slow to permit the suspended solids which it contains to deposit; it is in these deposits that most active bacterial actions are maintained. It would be difficult for anything like intense bacterial action to take place in a flowing stream of sewage, especially a stream flowing at this relatively high velocity where the particles of suspended matter are kept in suspension or kept moving. The opportunity for bacterial mass action is slight.

Q. Have you made any observations or studies upon the effect of sewage pollution on fish life?

A. Yes sir.

Q. What has been those observations?

A. I have been more or less interested in the *a*ffect on fish of sewage matters for a dozen years. My first study of this question was in St. Louis in connection with the Chicago Drainage Canal Investigation, and more recently within the past year in connection with an investigation conducted by me for the New York State Conservation Commission into the question of shell fish pollution in Jamaica Bay.

Q. At St. Louis were your studies directed to shell fish or to major fish life?

A. They were directed to major fish life.

Q. In that investigation did you attempt to determine whether the meat of the fish was affected by sewage pollution?

3604 A. We were more particularly interested to determine whether these fish would take up pathogenic germs, and if these germs would be propagated, or if they would multiply, within the fish, and that that fish perhaps, migrating to a water of purer quality, might discharge these pathogenic germs and thereby render it dangerous for consumption.

Q. What did you determine in this investigation?

A. We determined that practically all of the fish to be caught in the Mississippi River, near the month of the Illinois River, which receives the discharge of the Chicago drainage canal, did contain at one time or another intestinal bacteria which had come from sources in the sewage of the sanitary district of Chicago, or at least so we were led to believe. The bacteria so gathered in by the fish did not multiply within the fish and could not be found within the meat of the fish but only in the intestinal contents thereof.

Q. Have you ever attempted to determine what percent of dissolved oxygen in the water enables fish to live?

A. No sir; I have not; I know that such observations have been made and I know in a general way what the results have been. Conversation with American and British sanitarians which have carried on such investigations, has led me to the conclusion that major fish life, with a few exceptions, can exist in waters in which

the dissolved oxygen contents is reduced to about thirty percent saturation, and in some cases even less than that.

Q. Have you from your own personal observations reached any conclusions as to what was the trouble with the shad, for instance, caught in New York Bay and Hudson River?

A. I have, yes sir.

Q. What is your opinion in reference to that?

A. For many years the Hudson River shad has been a
3605 back number and has passed out of use at least, because of the fact that the meat of these fish when caught is so permeated with the tastes of oil as to be highly unpalatable.

Q. What kind of oil?

A. It has always the taste of kerosene, petroleum.

Q. I think you said you made a recent study of some parts of New York harbor or Bay with reference to shell fish?

A. I did, yes sir.

Q. Where was that?

A. That was in the waters of Jamaica Bay.

Q. Did you find those waters particularly adapted under normal conditions to the propagation of oysters?

A. Under normal conditions I consider the waters of Jamaica Bay about the best that can be conceived of for shell fish cultivation.

Q. Is or is not — the home of the famous Rockaway oyster?

A. It is, yes sir.

Q. And Jamaica Bay is, I think, entirely within the State of New York is it not?

A. It is, yes sir.

Q. What results did you reach in your examination of the shell fish or oyster industry in Jamaica Bay in your recent investigation?

A. The waters of Jamaica Bay are very shallow and teem with microscopic life upon which shell fish feed; the water is about the desired degree of salinity for the favorable cultivation of shell fish; the bay has but one inlet, which also serves as an outlet to and from the sea, and breathes twice a day with the tide. The conditions as I have said, for shell fish cultivation are naturally ideal, but unfortunately the city of New York discharges hugh volumes of sewage into this bay, the daily amount averaging between twenty
and forty million gallons, daily. This sewage is passed
3606 through sewage disposal works before being discharged into the bay, but all of these works are inadequate in design and insufficient, and do little beyond removing a small amount of the suspended matters originally contained in the sewage. It so happens that this sewage from these various outlets on the north, east, west and south shores of the bay is diffused throughout practically the entire bay. It is a further fact that there are only small isolated areas into which the sewage does not penetrate apparently. The surprising fact developed in this investigation was the fact that whenever the sewage was carried by the currents—wait a moment, thought. This report has not been published and I may be jumped

on by the Conversation Commission of New York for giving it out.

Q. So far as you know are there any processes applied to the sewage discharging into Jamaica Bay which would serve as germicides for the pathogenic germs in the sewage?

A. Chlorine gas is said to be used at some of these works and during my investigations of the twenty sixth ward's plant in 1906, was being used, but with poor effect so far as its germicidal properties were concerned. Therefore it may be said that the attempt to destroy pathogenic germs in the sewage treated at these various plants around Jamaica Bay has been futile.

Q. In your opinion what result has already been reached, so far as the shell fish industry in New York Bay is concerned by the discharge of sewage from the greater city of New York?

A. The shell fish industry has been driven out of New York harbor by the successively greater pollution contributed to it in years past. There are a few isolated shell fish grounds in New York harbor from which shell fish still continue to be dredged but not with the authority of the City or the state, and *whatever* detected, it *is* my understanding that such oysters have been confiscated.

3607 Q. Assuming that germicidal application shall be made to the sewage now emptied into the waters of New York Bay, for the destruction of pathogenic germs, in your opinion can such process be applied to the sewage of the Passaic Valley district at the treatment works?

A. It can, and effectively, if occasion arises in the future to make necessary such treatment.

Q. If New York takes the precaution to preserve its shell fish industry by treating its sewage with germicides for the destruction of pathogenic germs, the sewage of this district will be susceptible to like treatment?

A. It will.

Cross-examination by Dr. O'Sullivan:

Q. Do you hold yourself out as a sewage expert, Mr. Johnson?

A. I do, yes sir.

Q. Did you ever study at any of our institution- for the education of a civil engineer?

A. I have attended lectures and am an associate member of the American Society of Civil Engineers.

Q. Is that a teaching institution?

A. It is.

Q. Have you ever taken any degree in civil engineering?

A. No sir.

Q. Have you ever taken any degree in bacteriology or biology?

A. No sir.

Q. Have you ever taken any degree in chemistry?

A. No sir.

Q. Have you ever taken any educational degree at any of

3608 our teaching institutions?

A. No sir.

Q. You stated that among your experiences that you began as an inspector at Louisville, Kentucky, in 1895, is that right?

A. Yes sir.

Q. Later on you were assistant to Mr. George W. Fuller in his work there on water purification?

A. Yes sir.

Q. In 1899 you were an assistant under Mr. Miller and Mr. Robert S. Westson, were you not, in Washington?

A. I think that is the winter of 1898-9 that I was in Washington in direct charge under Colonel Miller and Mr. Westson of the experiments being carried on there into the purification of the Potomac River water.

Q. Did Mr. Westson direct the work there?

A. He was located in Boston and I reported to him each month.

Q. Who is Mr. Westson?

A. He is a sanitary expert, with offices at 14 Beacon Street, Boston.

Q. And is re-gnized as an authority on biological chemistry, is he not?

A. Yes sir; he has been associated with me on numerous occasions.

Q. On this occasion you worked under his direction, did you not?

A. Yes sir.

Q. Did you read his testimony as given in this case?

A. I have read much of it, yes sir.

Q. In the Chicago Drainage Canal investigations under whose charge was your work, and under whose direction?

A. My work was under the charge of the Water Department. originally, later being shifted to the Health Department.

3609 Q. Did you work under the direction of Dr. Ravold?

A. No sir.

Q. Was he not in charge of those investigations?

A. He was my associate; he was nominally in charge in his position as head bacteriologist of the city.

Q. Did you do any bacterial work there?

A. Yes sir.

Q. Was he your superior in that work or were you his superior?

A. He was my superior.

Q. The work that you described in 1901 was done directly under the supervision of both Messes. Herring and Fuller, was it not in Philadelphia?

A. Mr. Herring was engaged for that work and placed me in direct charge of it he directing it from New York.

Q. And that related to water filtration?

A. Yes sir.

Q. The various matters that we have just now dealt with were all water purification schemes, were they not?

A. Up to this time, with the exception of the Chicago drainage canal.

Q. Was not the investigation in that case directed to the influence of the drainage canal on the water supply of St. Louis?

A. Yes sir, the effect of the sewage of the Chicago drainage canal on the water supply of St. Louis.

Q. And you were investigating the condition of the water supply of St. Louis?

A. I was investigating the effect of the sewage of the drainage canal *of* the water supply, tracing it back to its original source.

Q. But your examinations dealing with water or sewage in that particular connection?

A. Both.

3610 Q. Did you examine the water to find sewage, or the sewage primarily to discover how much it might possibly affect the water?

A. I took both things into consideration, examining bacteriologically and chemically the sewage as discharged at the Bear Trap Dam, and tracing it from that point through its four hundred miles of travel to the in take of the St. Louis water works.

Q. And did such work as you were doing contemplate a report as to whether or not the sewage rendered the water unfit for potable purposes?

A. More particularly was the investigation aimed at the determined whether pathogenic or diseases producing germs were carried from Chicago to the water supply of St. Louis; in that respect yes.

Q. And you found — were carried to it, did you not?

A. I did not.

Q Did you consult the work done by Dr. Ravold previously on this very same subject?

A. The work that Dr. Ravold had done previous to the investigation, as taken up by me, had been done in fragments and the investigation was not continuous and therefore the results attained up to the time I took charge of it were considered to be of little value.

Q. Did you read Dr. Ravold's experimental work with the bacillus prodigiosus?

A. Yes sir.

Q. And that he proved that that traveled from the Chicago drainage canal outfall to the intake of the St. Louis water supply?

Mr. Riker: The question is objected to on the ground that it is immaterial and irrelevant and not cross examination.

3611 The Commissioner. Note the objection of counsel for the defendants.

A. As a matter of fact the test for the bacillus prodigiosus was my idea; I made the test primarily and as you have already intimated did find the same organism in the raw water of St. Louis, and considered this to be fairly good evidence, but in view of the fact that I have also personally isolated this germ from the Ohio River water I did not consider that it might not be a natural inhabitant of the waters of the Mississippi River. The tests made later by Dr. Ravold also disclosed *that* fact that this germ was at times pre-

ent in the tap water in St. Louis, and it was not inconceivable to me on that account that these germs that he found at a date subsequent to the time when I found them, might have come from the bacteria which I had personally added to the Illinois River months before.

Q. Is it not a fact that the baccillus prodigiosus experimented with by Dr. Ravold were brought from Europe, the cultures which he afterwards developed and which — afterwards experimented with?

Mr. Riker: The question is objected to on the grounds as last stated, and also as loading the record up with immaterial matter.

The Commissioner: Note the objection of counsel for the defendants.

A. So I understand.

Q. Did you read Dr. Ravold's testimony, in its digested form or otherwise, given in the Chicago drainage canal case?

Mr. Riker: The question is objected to on the same grounds as last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. I did, yes sir.

3612 Q. Does he in any way connect you with the experimental work with the baccillus prodigiosus?

Mr. Riker: The question is objected to on the same grounds as last stated, also on the further — that it is irrelevant as possibly showing the opinion of this gentleman of himself, but not of others, and that is not an issue in this case.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not recall that he did.

A recess was then taken.

Q. Mr. Johnson, what was the object of Dr. Ravold's experiment and the experimental work that you did with the baccillus prodigiosus?

Mr. Riker: The question is objected to on the same grounds as last stated, as immaterial, irrelevant and incompetent.

The Commissioner: Note the objection of counsel for the defendants.

A. We selected the baccillus prodigiosus for this test for the reason that it closely resembles in its actions and its resistance to unfavorable conditions of environments the typhoid baccillus; we wanted to ascertain whether the typhoid baccillus, if present in the sewage discharge of the sanitary district of Chicago would travel some three hundred and sixty miles between Chicago and St. Louis and enter the water supply of the latter City. We took the bacillus prodigiosus for the reason that it is easily identified on culture medium.

Q. Did Dr. Ravold later testify that he found and dis-
3613 covered the bacillus prodigiosus at the intake of the St. Louis water supply?

Mr. Riker: The question is objected to on the same grounds as last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. I believe that he did.

Q. You testified that you worked with the Maigen filter device at Philadelphia. Under whose direction did you do your work there in 1901?

A. My most active adviser in that work was Mr. Fuller, the partner at that time of Mr. Rudolph Herring, under whose charge these investigations were being carried on and directed from New York.

Q. The work that you did at Little Falls on the filtration plant there, under whose direction did you do that work, Mr. Johnson?

A. Under the direction of the chief engineer and superintendent of the Water Company, Mr. J. Waldo Smith, and the consulting engineer, Mr. G. W. Fuller.

Q. You testified that you did some work of a chemical and biological nature in regard to the additional water supply for New York City. Under whose direction did you do that work?

A. That was in the department of chemistry and biology, at the head of which was George T. Whipple who had the title of department engineer; my title was field director and principal assistant engineer.

Q. In the Waterloo Iowa works under whose direction did you do that in 1903?

A. I am consulting engineer to the Waterloo Water Company. The work was carried in under my full direction.

Q. What part did George W. Fuller play in the direction
3614 of that work?

A. None.

Q. He had no connection with it?

A. No sir.

Q. In what capacity did you do the work for the Columbus, Ohio, plant?

A. As engineer in charge of the testing station, the work being nominally under the charge of Julian Griggs, chief engineer for the Board of Public Service, also being supervised by the consulting engineers Herring and Fuller.

Q. Who was the chief engineer in charge of the work at that time?

A. Julian Griggs.

Q. Who was the chief chemist in charge of the work?

A. I know of nobody by that title.

Q. What title did Mr. A. Elliott Kimberly bear?

A. He was my principal assistant chemist.

Q. Were you chemist in charge?

A. I was the engineer in charge.

Q. Who was chief of the chemical staff?

A. I was.

Q. Who was chief of the bacteriological staff?
A. I was.
Q. What position did Mr. Clarence C. Hoover occupy?
A. First assistant bacteriologist, after the resignation of Mr. William R. Copeland, who was first assistant bacteriologist until May 1905.
Q. Did not Mr. George E. Wilcomb take the position occupied by Mr. Copeland?
A. For a short time, about six weeks.
Q. Who did the actual bacteriological work?
A. The second assistant did the routine work, Mr. Cope-
3615 land special work.
Q. Under Mr. Copeland's direction?
A. Under my direction.
Q. Mr. Copeland, you say, was an assistant?
A. Yes sir.
Q. So that you were chief chemist and chief bacteriologist directing the work of both departments in the Columbus, Ohio, plant, during 1905 and until 1906?
A. My title during the work of 1904-5 was engineer in charge and as such I directed the work of three departments, engineering, chemical and bacteriological.
Q. Did you collect any of the samples that were subjected to chemical analyses?
A. I did.
Q. Did you conduct any of the chemical analyses?
A. I did.
Q. How many assistants were there altogether in the chemical department?
A. Altogether there were three assistant chemists, Mr. Wilcomb the third man, and—that is all, there were three altogether in the chemical department.
Q. How many bacteriologists were there during the bacteriological work?
A. There were four, Mr. Wilcomb being one, and he, as before stated, served for six weeks.
Q. Was there not a fifth, a Mr. Jennings?
A. In the first part of the work Mr. Jennings served for a few weeks.
Q. Did any of the chemists collect any of the samples subjected to chemical analyses?
A. Almost without exception, all these assistants mentioned, on pages 9 and 10 of the Columbus report on sewage purification, writ-
ten by me, took samples at one time or another for analyses;
3616 the routine duty of sample collection was in the hands of the inspectors, of whom there were five in all.
Q. So that you did the duty of inspector of chemist and of bacteriologist on this work; is that right, Mr. Johnson?
A. Well, at one time or another, yes; but it was my duty to direct the work of each department from the office, as is done in all such work as this, and in all lines of mercantile work.

Q. What engineering work did you do in connection with that plant?

A. The engineering work referred particularly to the operation of these various forty four devices which were under test and that referred to gauging the rates of filteration and such other things as would naturally come up under the general head and operation of sewage purification.

Q. Was the plant constructed and in operation before you were installed?

A. No sir.

Q. Did you have anything to do with the construction of the plant?

A. I was there during the latter part of its construction.

Q. Did you have anything to do with the construction work directly?

A. No sir, that was under the charge of Mr. Kimmler, an assistant engineer from the city engineer's office.

Q. Altogether what did the entire staff number both in the chemical and bacteriolgical work who did this chemical and bacteriological work?

A. They averaged about nine men.

Q. Look at page nine of that report and see if you did not state positively that they averaged fourteen men.

A. You asked me how many were engaged on chemical and bacterial work; fourteen includes the inspectors.

3617 Q. Were they not engaged in securing the samples?

A. Yes sir. They did not do analytical work.

Q. Did they not collect most of the samples that were worked upon later by both the chemists and bacteriologists?

A. They did, that was their duty.

Q. Did not you have two assistant engineers on that staff, too?

A. Yes sir.

Q. And all those men reported to you and you fashioned their reports into a report for your superiors in that Columbus plant?

A. The head of each department reported to me every morning for instruction, which he followed during that day's work. At the close of the week they each presented a report setting forth the results which they had obtained during that week's time, and the result of all those reports I prepared of each month, setting forth the progress of the work and after its completion I prepared the final report which was published by the city in 1905.

Q. And all that work of the staff which you have just been describing and your own work was under the supervision of Mr. George W. Fuller?

A. He was an advisor.

Q. Who supervised the work?

A. Hering and Fuller consulting engineers, and Julian Griggs chief engineer.

Q. In 1906 you described a tour in which you made investigations of sewage disposal systems; was that confined to sewage disposal plants in those locations?

A. No sir.

Q. Did you travel in the interests of any particular device for water purification?

A. I traveled as the expert of the Jewell Export Filter Company.

3618 Q. Is that a patented device?

A. What, the filter company?

Q. The Jewell Export Company?

A. They have patents, yes.

Q. And these were calculated to improve the water supply wherever they were put in use, is that so?

A. They are, yes sir.

Q. In 1907, on your return from this tour, in the interest of the Jewell Export Filter Company, did you enter the service of Hering and Fuller?

A. Yes sir.

Q. As an assistant?

A. As an assistant engineer, yes sir.

Q. Were you at any time connected with the Jersey City Water Supply Company?

A. Yes sir.

Q. What year was that, Mr. Johnson?

A. 1908 and 1909.

Q. Did you make any investigation of the water supply?

A. Yes sir.

Q. Did you later testify in a suit in which the purity of that water was at issue?

A. I did, yes sir.

Q. And you testified in favor of the Water Company and against Jersey City.

A. That is true, yes sir.

Q. Did you change your attitude at any time later with regard to the potable water that was in issue at that time between the Jersey City Water Supply — and Jersey City?

A. I did, yes sir.

Q. When did you make that report to Jersey City?

3619 A. December 7, 1912.

Q. Did the testimony which you gave in 1910, in favor of the Jersey City Water Supply Company conflict with the report given to Jersey City on the same topic and which was given in 1912, in December?

A. No sir, in no particular.

Q. When you were a witness for the Jersey City Water Supply Company did you not testify that it was not necessary to purify the sewage before discharging it into the water supply?

A. No sir, I think not.

Q. Are you positive, Mr. Johnson.

A. You have the record you can read it to me, and I can tell you whether I said so or not. There are a number of assumptions that have a good deal to do with the answers we give to certain hypo-

thetical questions, which a number of people seem to have misinterpreted.

Q. As you recall your testimony didn't you positively state in this case under oath that it was not necessary to purify the sewage before discharging it into the water supply?

Mr. Riker: The question is objected to on the ground that the witness has already answered it.

The Commissioner: Note the objection of counsel for the defendants.

A. I should much prefer to see the testimony if you have it; I think it would be better to read it.

Q. Is that your best answer?

A. Most assuredly.

Q. Didn't your report in December, 1912, to Jersey City urge the necessity for the purification of the sewage before it was discharged into the water supply?

A. It did, for the very good and sufficient reason that the condition- on that water shed have changed materially since the testimony I gave in the New Jersey suit.

3620 Q. What changes had taken place in those two years?

A. The degree of pollution of the feeders of the Boonton reservoir.

Q. Had the volume of sewage increased?

A. It is difficult to state in precise figures, but I should judge that it had.

Q. Had the character of that sewage been in any way altered?

A. Judging from analyses as have been made since the time I gave my testimony and such analyses as were made before I gave my testimony, the fact is plain that the water has been gradually growing worse and worse each successive year, indicating clearly that the amount of pollution contributed to the Boonton reservoir has been increasing year by year?

Q. Quantity?

A. As to quality.

Q. Now as to the character, or equality of the polluting media, how about that?

A. I should say the same thing in regard to the quality, because the bacterial analyses show a steady increase up to the present time.

Q. Have they added any new plants in those two years, that have contributed extra amounts of sewage or sewage of more polluting character?

A. I could not testify as to that, the evidence at the other end is good enough for me although I have been over the watershed and personally viewed its unsanitary condition. In 1908 the quality of the water was such that in the opinion of all who were connected with the case, and of myself in particular, the water was not so polluted but that it could be effectively made safe for human consumption by the addition of a sterilizing agent at the dam. This sterilizing method had only then come into vogue, as a matter of fact I put it into use for the first time in this country in connection with

the purification of the water supply of Bubbling Creek in the
3621 Union Stock Yards at Chicago, in September, 1908.

Q. What was that agent?

A. Hypocholoride of lime.

Q. When did you first advocate the use of hypocholoride of lime as a sterilizing agent?

Mr. Riker: The question is objected to as being entirely without the issue, immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. May 11, 1908.

Q. Had it not been described long before that by Professor Earl B. Phelps?

A. In connection with the treatment of the sewage I think it had but not with the purification of water in this country.

Q. Are you quite sure of that?

A. If it had been described it had never been used.

Q. Had it not been used at the Lawrence experimental station in sewage?

A. I am speaking of water.

Q. And had it not been used on water?

A. I think not, in fact I am positive it had not.

Q. Your testimony in 1910 opposed the use of this sterilizing medium, didn't it?

A. No sir.

Q. Did you advocate it?

A. I recommended it.

Q. For sterilizing the waters?

A. Yes sir.

Q. And that obviated the necessity of in anyway purifying the sewage?

A. At that time, yes sir.

3622 Q. And later on, two years later, you advocated the purification of the sewage in addition to the sterilization of the water did you not?

A. I did, and for this reason:—In 1908 when this process was recommended for adoption by the Jersey City Water Supply Company, for use at Boonton, we had in this country very little experience in the line of what hypocholoride would do in that respect we were on insecure and indefinite grounds as to the limitation of the process; we knew that under the conditions to be met in the treatment of the Boonton supply this process was safe and effective we assumed that the amount of pollution on the water shed would not grow materially less in years to come. But since that time we have learned the limitations of the process and we know that you cannot go on indefinitely, adding indefinite amounts of hypocholoride of lime to a water without imparting to that water undesirable and inadmissible tastes and odors of the chemical itself. As the organic matter on the water shed, washed into the river, increases the organic matter in the reservoir itself necessarily must in-

crease, and because of this increase in the polluting matter it becomes necessary to use greater quantities of the germicidal agent than were required when we first started the process. The limit is rapidly approaching. We know positively that when we add to the Boonton water a quantity of the germicidal agent three times in excess of that which we started with, the water is given an objectionable taste. We have already doubled the original dose to meet the requirements of the increased pollution.

Q. When you said you doubled the original dose do you mean the dose that you advocated in 1910?

A. Yes sir.

Q. Did Jersey City loose or win that suit?

A. They lost it.

Q. In all of the matters that we have now been asking and
3623 answering questions on, did they all relate to fresh water conditions?

A. Yes sir.

Q. Did you ever design and construct and put in operation a sewage disposal plant?

A. So far as any consulting engineer ever does design, construct and put in operation a sewage or any plant, I have.

Q. Where?

A. Take the case of Reading, Pennsylvania, where I was associated with Hering and Fuller. The plans for this work were prepared in the office at 170 Broadway, and there, and at Reading, in the office of the resident engineer, I advised as to features of design throughout the preparation thereof. During the construction of these works I advised the resident engineer as to various features of the construction work, and at times actually took his place. As far as the operation of the work is concerned I was the active representative of the firm Hering and Fuller throughout the entire work.

Q. And under the direction of both Mr. Hering and Mr. Fuller of the work done?

A. That is not so because that was a piece of the work which was given over to me and I advised with them as to its prosecution.

Q. Before adopting any plans in the furtherance of the work itself?

A. I cannot say that because there were many steps taken in the construction of the plant in its operation that I personally directed without advise from anybody.

Q. Are you now in the employ of *the* New York City in any particular capacity?

A. No sir, but I am subject to call as I have been for many years.

3624 Q. What Department of New York City have you served?

A. The Department of water supply, gas and electricity.

Q. In what capacity?

A. As consulting engineer.

Q. Are you now an employee of the City of New York or any of its departments?

A. No sir.

Q. When did you sever your connection with the New York State Conservation Commission?

A. June 11, 1912.

Q. You testified to some work done during your connection with the New York State Conservation Commission; I ask you who did the bacteriological work with reference to these shell fish?

A. There was none done.

Q. Who did the chemical work relative to the condition of the water flowing over these oyster beds?

A. There was no chemical work done in this investigation.

Q. Who did the microscopical work relative to the deposits, or the water that covered or surrounded these oysters in Jamaica Bay that you mentioned?

A. We relied for such information as your questions speak of upon published reports of such work done by the members of the Water Department, the Sewer Department, and the Metropolitan Sewerage Commission.

Q. All employees of New York State and New York City?

A. Yes sir.

Q. Did you depend to any extent upon the bacteriological or other work done by Dr. Stiles of the Federal Government?

A. Very little, his bulletin was not published at the time my report was made.

Q. Were you familiar with any of the facts which later appeared in that bulletin?

3625 A. Yes sir.

Q. And prior to its appearance in published form?

A. Yes sir.

Q. The matter which you have testified to relating to the New York State Conservation Commission, has that been published yet?

A. It, I understand, is in the hands of the printer.

Q. But has it been actually published?

A. Not to my knowledge.

Q. The matters which you have testified to you have gathered during your connection with the New York State Conservation Commission?

Mr. Riker: The question is objected to because it is assumed that he has testified to no matters gathered in that way, the fact being that he declined to testify as to the contents of that report.

The Commissioner: Note the objection of counsel for the defendants.

A. With regard to Jamaica Bay, if that is what your question relates to, I would state that such statements as I have made are not entirely based upon this report but upon personal observations made years ago with respect to the amount of sewage entering the harbor, its direction and flow.

Q. How many years ago?

A. Six.

Q. What work did you do in Jamaica Bay six years ago?

A. I made an investigation of the sewage works about Jamaica

Bay under Mr. Hering, for the Department of Sewers in New York in the winter of 1906 and '7.

Q. Who was in charge of that bureau in Brooklyn at that time?

A. I could not tell you. Furthermore I must amend that statement by saying that this investigation was made for chief
3626 engineer Lewis of the Board of Estimates and Appointments and not for the Bureau of Sewers.

Q. Do you know who was in charge of the Brooklyn sewers at that time?

A. I was trying to think, but I cannot recall now. The present chief engineer is E. J. Fort.

Q. Was he in charge at that time?

A. I think not.

Q. What investigations did you conduct at that time that had any relation to the oysters or oyster beds?

A. I made an investigation of each of the sewage works with the view of ascertaining whether they were doing the work required of them and whether the effluent as discharged in Jamaica Bay was of the character which was required.

Q. Did you examine any samples of the oysters?

A. No sir.

Q. Did you examine the oyster beds themselves?

A. I did not. You refer I suppose in that question to 1906?

Q. You said about six years ago.

A. That is right.

Q. I am speaking of that time.

A. I so understand.

Q. When did you actually make any personal observation either in relation to the oysters or the oyster beds?

A. In the early part of 1912.

Q. You were then employed by the New York State Conservation Commission?

A. Yes sir.

Q. And in your position and your relation towards them you made investigations?

3627 A. Yes sir.

Q. Did you make any report on it?

A. I did.

Q. And the report has not been published up to date?

A. To my knowledge it has not.

Q. What you have testified to relating to oysters and oyster beds is entirely predicated on the observations you made at that time?

A. No sir.

Q. What other observations did you make beside those you made for the New York State Conversation Commission in relation to oysters or oyster beds?

Mr. Riker: The witness has been asked the question and answered that he made observation in 1906, in regard to Jamaica Bay in connection with the sewers, and I object to the question.

The Commissioner: Note the objetcion of counsel for the defendants.

A. The whole question of oyster pollution or shell fish pollution has been one in which I have been interested for a great many years, but so far as making personal observation is concerned, bacteriologically, I have made none. My information has been gathered from visits to various places where the shell fish industry was involved and by close attention to the literature on the subject which has appeared from time to time.

Q. Have you ever at any time conducted bacteriological examinations of either oyster liquor or oysters?

A. I have for my personal satisfaction, the work being done at Cincinnati in 1908.

Q. Is that work printed or published in any form?

A. It is not.

3628 Q. What is greening in oysters due to?

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. That is a technical term; I presume the answer you require is that greening is due to the algæ which are taken in by the oysters as food, although a typical greening of oysters is brought about in some waters of Europe, particularly on the coast of France, by the presence in those waters of copper compounds.

Q. Have you ever found greening in any of the oysters taken from any of the waters of New York Harbor?

A. I testified I made no examination of oysters in Jamaica Bay. It was not necessary.

Q. When were you connected as one of the commission-s of New York City in the department of water supply on the Jerome Park Filter Plant?

A. June, 1912.

Q. When did you sever your connection.

A. June, 1912. I did not sever it, it was severed.

Q. When were you first connected with the Passaic Valley Trunk Sewer project?

A. It may have been the very last part of 1906 but it is my impression that I began work on it in the early part of 1907.

Q. What work did you do then?

A. When this work was taken up by my office, at the office of my firm——

Q. What firm was that?

A. Hering and Fuller—in the office, I was the assistant engineer; the department given me to work up was the disposal of the sewage, which related to study as to its composition and the

3629 trade waste problem.

Q. Did you make a study at that time of the trade wastes of the Passaic Valley that were discharged into the Passaic River?

A. I did, yes sir.

Q. Occupying how long a time during 1907?

A. The investigation extended over some six or seven months

I should say, consecutive months, all the time of which was not devoted to this work, and furthermore there were days spent on it even after that. The bulk of the work was done within six months' time.

Q. And was chiefly what so far as you were concerned, what was the character of the work?

A. Laying out instructions for the field force to follow, examining their reports, recording the results and making personal trips to check up the results recorded by them.

Q. What did the field force consist of, chemists, bacteriologists, engineers or what?

A. The field force was in charge of Mr. Samuel A. Greeley, but the names of the members I cannot recall; there was one whose name was Charles E. Weltner.

Q. In connection with the trade wastes and the sewage being discharged in 1907 and for the six months that you were occupied in investigation it, did you do any bacterial work in regard to that sewage or trade wastes?

A. No sir.

Q. Did you do any chemical work?

A. Sometimes chemical work was done, yes sir.

Q. What did that consists of?

A. That refers to trade wastes, does it?

Q. Either sewage or trade wastes.

A. It referred to the determination, in the case of trade waste only of dissolved oxygen.

3630 Q. Relative to sewage, what did it consist of?

A. That is what I referred to, not in connection with the trade wastes.

Q. How did you find the oxygen contents of such part of the Passaic River as you examined at that time?

A. We selected thirteen sewer outlets as follows:

No. 1. In the Passaic sewer, opposite Dock St. Sewer 4′ 10½ x 3′ 6″. This sewer drains storm water from 650 acres and house sewage from 30 acres.

No. 2. Lafayette St. sewer, 20″ diam. drains house sewage from about 620 acres, storm water from about 30 acres.

No. 3. Lodi St. sewer, 20″ diam. Drains area of 100 acres largely built up with factories.

Rutherford.

No. 4. Pierpont Ave., sewer 24″ diam. House drainage from 138 acres.

Second river.

No. 5. Orange, Bloomfield, Glen Ridge and Montclair Joint Sewer. Diam. 45″. Drains 9,358 acres.

Mr. Riker: I ask to have that joint sewer at Second River excluded on the ground that the municipalities just mentioned are not within the territory to be drained by the Joint Sewer.

The Commissioner: Note the request of counsel for defendants.

Witness (continuing): Newark.

No. 6. Carlisle Place Sewer 6′ 9″ x 9′ 3″. Drains an area in Newark of 1,750 acres and in East Newark of 2,427 acres.

No. 7. Vernon Ave. sewer, 5′ 3″ x 6′. Drains an area of 1,206 acres.

No. 8. City Docks, sewer 5′ 6″ x 6′ 6″. Drains the most
3631 densely populated part of the city. Area of the drain 355 acres.

No. 9. Jackson St. sewer 4′ 10″ x 4′ 13″. Drains an area of 281 acres.

No. 10. Freeman St. sewer 4′ 0″. Drains an area of 149 acres. Kearny.

No. 11. Johnston Ave., sewer 7′ 0″ x 3′ 3″. Drains 242 acres. East Newark.

No. 12. Central Ave., 4′ 0″ x 2′ 8″. Drains an area of 859 acres. Harrison.

No. 13. Harrison Ave., Sewer 4′ 0″ x 2′ 8″. Drains an area of 106 acres.

The samples were taken from the discharge of these sewers on November 13th and 14th, 1907, and for the most part in the afternoon or near noon. The percentage saturation in dissolved oxygen of these samples, in the order given above was as follows:—70, 45, 35, 2, 42, 47, 73, 57, 26, 17, 28, 10, 7.

These samples so far as being influenced by bank water were collected, to the best of my knowledge and belief, at low water.

Q. Who collected those samples that were subjected to these chemical analyses to determine the oxygen contents?

A. They were collected to the best of my recollection and I think I am correct, by Charles F. Breitzke.

Q. Who employed Mr. Breitzke?

A. He was an assistant in the office of Hering and Fuller.

Q. Who made the chemical analyses?

A. He did on the ground.

3632 Q. How near the out fall were the samples taken?

A. His instructions were to take them at the first manhole after leaving the river.

Q. The first manhole after leaving the river?

A. Yes, sir. He located the outlet and then walked back on the line of the sewer until he came to his manhole.

Q. Then if I understand you right these samples were not taken from the river, they were taken from the sewer?

A. From the contributing sewers, yes, sir, to get an idea of the character of the sewage that would ultimately enter the trunk sewer.

Q. What part of the work did you contribute at that time?

A. This was the time when I was directing the whole investigation, and when I periodically went out on the shed myself and checked up the results of investigations made by my assistants.

Q. In some of the samples of sewage collected as you have described you found as high as 70 per cent oxygen contents?

A. 73.

Q. 73?

A. Yes, sir.

Q. You also found 70 in a sample or some samples?

A. Yes, sir.

Q. The lowest of the determinations being 2 per cent and the highest 73 per cent; is that right?

A. That is correct.

Q. You made none of those oxygen determinations yourself, did you?

A. No, sir, I made none.

Q. Were any samples taken under your direction at that time from any part of the Passaic River?

3633 A. No, sir. For the purpose of determining the amount of dissolved oxygen in the Passaic River, we did not think it was necessary.

Q. Did you expect that it would be higher or lower than in the sewers?

A. We knew that it would be lower.

Q. So that the sewers discharging into the Passaic River have a refreshing action on the Passaic River?

A. I think unquestionably, as discharged, that they have.

Q. They had in 1907, and do they still exercise that beneficent influence?

A. I think they do temporarily, until the low velocities permit the heavy matters to deposit on the bed on the stream there to be later putrified.

Q. What other work did you do at this stage in the Passaic Valley Sewerage Commissioners investigation or work, in 1907 or 1908?

A. That was all of the work I had charge of.

Q. Was there any bacteriological work done at that time under your direction?

A. No, sir.

Q. Was there any engineering work done by you or under your direction at that time?

A. Only such engineering work as you might put under the head of investigation as to trade wastes in the determination of the volume, but that is hardly engineering work inasmuch as it entails merely the measuring up of tanks from which these waters are discharged in order to get at the volume.

Q. What work did you do on the trade wastes at that time?

A. Investigation of the trade wastes problem was begun, as I have already testified, in the early part of 1907, and carried through, practically, the entire year, but the bulk of it was done in

3634 the first six months after the work was started. Our endeavor was to ascertain the volume of discharge of various objectionable trade wastes from the various establishments of the Passaic River discharging into it, and we considered that such information would prove valuable in not only aiding the engineer in charge of the design of the sewer in fixing the size of the sewer, but also would give us a clue as to what part, in the composition of the sewage was played by the trade wastes themselves. In prosecuting this investigation men were sent out from the office of Hering and Fuller bearing directions from me as what to do, and they visited the various

manufacturing establishments in the Passaic Valley water shed as would be likely to have objectionable trade wastes. A list of such establishments was previously prepared in the office from business and factory directories. In the case of Paterson we did not go into details for the reason that an investigation had only been made, in the years 1905 and 1906, by Mr. George C. Whipple, and his results had been reported in the reports of the City of Paterson.

Q. Do you mean Whipple or Hazen?

A. Whipple of Whipple and Hazen; his report was incorporated in Mr. Hazen's report.

In all the men from the office of Hering and Fuller visited two hundred and fifteen establishments, and of these one hundred and twenty-six, or about sixty per cent, were found to be important as regards offensive trade wastes, and full data were secured at these establishments relating to the location of the plant, the kind of industry, and the general character of the wastes and where and how they were discharged into the Passaic River, or whether they were discharged into sanitary sewers or otherwise. We got at the volume of discharge per day and per hour; in eighty-nine places the wastes were found to be insignificant as regards volume.

3635 Do you want the details of this, Doctor?

Q. I would like them very much, Mr. Johnson.

A. In Paterson sewage, the most northerly point the discharge is 2,700,000 gallons of trade wastes each day. Those are objectionable trade wastes, wastes that cannot be separated from the wastes and which enter the Passaic River without creating a nuisance. These wastes contained spent dye stuffs, soap, and considerable suspended matter.

Saddle River Township. The wastes from the dye stuffs at Rochelle Park amounted to 100,000 gallons per day, and contained spent dye, some soda some soap.

Passaic City. The wastes from woolen and worsted mills, breweries, paint works, etc., amounted to 1,432,000 per day. They contained spent dyes, spent acids and alkalis, yeast and soap.

Lodi Borugh. A bleachery and dye works discharged 600,000 gallons of wastes daily. The discharge contained spent dyes and bleach and some sulphuric acid and soda.

Carstadt Borough. A small chemical plant discharged 2,000 gallons daily of waste products.

East Rutherford Borough. A bleachery at Carlton Hill, and a manufactory at Rutherford discharged each day 1,020,000 gallons of wastes, contained spent dyes, acids, gums, and starch, caustic soda, bleach, sand and powdered glass.

Nutley town. Two paper mills and one wool carding establishment, one oil works and a cutlery works, discharged about 1,094,000 gallons of wastes daily, containing pulp, lime, bleach and soap.

Belleville Township. A hat factory and four other establishments discharged 110,000 gallons of wastes daily, containing spent dyes, acids and fur.

Bloomfield Township. Here there was a paper mill, a hat fac-

tory, woolen mill, wall cover establishment, and two other
3636 establishments discharging 468,000 gallons of wastes daily, containing bleach, powder, some pulp, spent dyes, fur, traces of acid and a small amount of soap.

Glen Ridge. About 500 gallons of iron pickling.

Montclair. A paper coating works, discharged about 400 gallons daily of spent stuffs, chloride of lime, and copper su-phate. Five pounds of copper sulphate are used each day.

Orange. Ten hat factories and one brewery discharged each day 850,000 gallons of wastes, containing spent dye stuffs, traces of acids and considerable suspended matter.

East Orange City. Two establishments here discharged 17,500 gallons of wastes each day containing bleaching powder, caustic soda, soap and spent dyes, essentially.

Kearny. An *abitur* and linoleum works discharged daily a total of 100,000 gallons of wastes containing traces of acids, some lime and some hair.

East Newark. A thread Company discharged each day 212,000 gallons of wastes, containing spent dyes.

Harrison. A wire works and a battery discharged 155,000 gallons daily of wastes.

Newark City. The breweries, hat factories, and tanneries contribute over one half of the trade wastes of Newark and contain spent dyes, acids and soda, lime, salt, etc. The remaining wastes are varied in character.

Q. Did you make any computations with a view of determining the trade wastes from these two hundred and fifteen establishments which you examined in 1907?

A. Yes sir, we did, and they are as given above, the total being 12,878,000 gallons daily. Of this, it is understood that some 2,900,000 gallons come from communities which have withdrawn from the Passaic Valley Sewer District, leaving a net in 1907, of about 11,000,000 gallons daily.

3637 Q. In that computation, Mr. Johnson, did you withdraw the contribution of sewage and trade wastes of Bloomfield?

A. I did in this computation I have just made.

Q. Do you know whether or not, within two or three months, Bloomfield has applied for permission to participate in the Passaic Valley Trunk Sewer project?

A. I do not, but I have understood that the period of time given these various communities to signify their intention of coming in has expired.

Q. Was Bloomfield a member of the communities that were to enter into this project in 1907?

A. I so understood, yes sir.

Q. Which way did you understand it, that it was one of the communities?

A. I am quite certain it must have been, otherwise we would not have made these investigations.

Q. I understood you deducted Bloomfield from the gross amount?

A. In this statement which has just been made, placing the net

amount of trade wastes in 1907 at eleven million gallons, Bloomfield was deducted.

Q. And what was Bloomfield's contribution that should have been added?

A. 468,000 gallons daily.

Q. What did you estimate the contribution in sewage and trade wastes as being from the City of Newark?

A. The total amount of objectionable trade wastes there was estimated at 4,016,700 gallons daily.

Q. Who passed the question of whether the contribution was offensive or otherwise?

A. I did.

Q. What trade wastes and sewage did you regard as unobjectionable?

A. Water used for cooling in rolling mills, spent dyes in a highly diluted state, that is, the last wash, any wastes of that
3638 character that possess so little of the original trade wastes that their discharge into the stream would amount to nothing in the way of lowering its oxygen contents or adding any color to it.

Q. In your investigation of Pittsburgh, Pennsylvania, did you have occasion to take into consideration these very spent liquors, and their precipitating effect on the sewage discharged in the Monongahela River?

A. I guess that was the Alleghany, was it not.

Q. Well, take the Alleghany.

A. Yes sir.

Q. Are you familiar with the conditions in the Monongahela?

A. Yes sir.

Q. Have they not the gravest problems arising from these spent liquors?

A. It is certainly no simple problem, it is a serious one. But is as much as that is a mining country, an iron and steel country, if they eliminated these trade wastes they cut off their own head.

Q. Yet the water is fairly clear after those spent liquors are discharged into it, *it* it not?

A. It is fairly clear for the reason that they exert at the point of discharge a precipitating effect.

Q. And particularly of collo*dial* matter?

A. That is very true, but the fact remains that the amount of pollution entering the Alleghany River, above Pittsburgh, that brings about this precipitation of collo*dial* matters is so much out of proportion to this proposition here that it is worthy of no consideration. So much of these wastes enter that stream there as to occasionally render it green or blue or brown, according to the stage of oxidation in which the iron compounds are as discharged.

3639 Q. What ill effect do spent liquors exercise on waters that are polluted by sewage?

A. Water that contains a great deal of spent dye, if out of proportion, will impart a color to the sewage; sewage that contains hair, or other suspended matter which easily sticks to the side of the sewer will cause clogging, and reduce the capacity of it. The same is

2481

true of grease. But it is a rule that is almost always adopted, to compel the owners of these industrial establishments to install at their own works purification devices, screens, small tanks and other things whose object it is to remove these matters before the sewage is allowed to discharge into the city sewers. The same thing would be true here. There is nothing unreasonable about it.

In making an investigation of this kind at Reading, Pennsylvania, we called the attention of the owners of certain hat factories there, to the fact that they were discharging large quantities of hair, fur, into the sewers, which were clogging them up; by putting in suitable screens and traps they recovered a great deal of this fur and actually derived a profit from it, so that we got thanked ultimately where we were thoroughly condemned in the first place. The same would be true here.

Q. Have they installed any such purification schemes for wastes known as spent liquors either on the Monongahela or the Alleghany?

A. I think not, no.

Q. Have they installed any such plants at any of the factories along the Passaic, where they discharged spent liquors?

A. Do you refer to spent dyes or spent liquors of any sort?

Q. Both.

A. Yes, sir, they have. With regard to Paterson I should have to look up the details of Mr. Whipple's investigation. I do not know whether that report is in the evidence or not; if it is the data are there.

3640 Q. I should be glad to have it in evidence if Mr. Riker agrees to it.

Mr. Riker: I will consider it, Doctor.

The Witness: At Rochelle Park the dye works discharge 100,000 gallons a day of spent dyes and wash water into the Saddle River, during six days of the week. Before reaching the river the waste passes through an unlined settling basin.

Q. Will sedimentation remove spent liquors, either the acids or the alkali that you have been describing?

A. If they are in proper combination, yes sir.

Q. What combination would they have to be in?

A. An acid with an alkali sometimes will form a coagulant and if it has the proper base it is conceivable you would get some precipitation in that way.

Q. Are you speaking theoretically now?

A. No sir, I am speaking practically.

Q. Give us an illustration for the Passaic water shed where these acids and alkali form precipitants by forming salts.

A. I could not call attention to any particular place, but it is perfectly conceivable. It is one of the integral parts of a mechanical filter process for filtering water and one in the integral parts of the chemical precipitation of sewage.

Q. Where did you say these purification processes were in operation now?

A. I was just running over them; the first one I have run across is at Rochelle Park.

Q. Is that in the Passaic Valley sewerage district?

A. That goes into the Saddle River; I think not. That has been withdrawn. Another is at Lodi, which has also been withdrawn; the wastes of a bleachery and dye works discharging 600,000

3641 gallons of wastes per day, they are passed first through settling basins before discharged into Saddle River or its tributaries.

Q. What is the object of a settling basin, to recover what?

A. Such suspended matters as the wastes may contain.

Q. What suspended matters do they contain, do you know?

A. I suppose the wastes from a bleachery would contain calcium chloride, calcium carbonate and possibly some solids from the dyes. I am not an expert on bleaching and dying but those are usual things. There might be fibrous matters probably and considerable dirt.

Q. And the object of the sedimentation is to recover this is it not?

A. It is to remove them before they are discharged into the stream, As a general proposition some people are philanthropically so inclined.

Q. Don't they use this sedimentation mass again?

A. I don't think they derive much profit from it.

Q. That is not the point; I asked you if they used them again.

A. I cannot say, I do not think so.

The wool carding establishment at Nutley discharges its wastes into a covered cesspool which overflows into the river but retains the suspended matters, and it is to be presumed skims off the grease; I do not pretend to know whether it does or not. The paper Mill wastes containing lime and bleaching powder and pulp are screened at Nutley before discharged.

Q. Will either of these last two methods you mentioned remove alkali or acids that are in the trade wastes; will either of the last two schemes you mentioned?

A. Oh no.

3642 Q. My question was originally directed to the one point as to what manufacturers had installed purification schemes for the removal of the spent liquors, these alkalise and acids wastes that you have told us of?

A. I do not think there are any such works in the Valley any where, because I think the quantities discharged are too small.

Q. Where they are large, as in the Pittsburgh district, are there any such projects or schemes for the removal of the spent liquors, either acid or alkaline trade wastes?

Mr. Riker: I enter an objection to the question in that it is not specific enough.

The Commissioner: Note the objection of counsel for the defendants.

A. I think not.

Q. Did you understand my question?

A. Yes sir. The plain facts are they allow these wastes to go direct into the river at the present time, for which they are removed from the waters used for public supply, at considerable expense.

Q. And the only way they could be removed would be by adding something that would form a salt and precipitate them is that so?

A. That is about right.

Q. In your investigation in 1907 and 1908 you accepted the report of Messrs. Whipple and Hazen to Paterson and took it without entering into any detailed investigations on your own part, is that right?

A. I selected from Mr. Whipple's data those wastes which were clearly objectionable; those wastes that were not objectionable I excluded. He recorded the total volume from Paterson City as being nearly 13,000,000 gallons a day in 1907, but the bulk of
3643 that was inoffensive and could be discharged into the Passaic River without nuisance.

Q. And you accepted it as it was in his report.

A. I won't say that I accepted the report as a whole.

Q. I say you accepted his details with regard to these trade wastes, as they were outlined in the report and discussed in the report?

Mr. Riker: The question is objected to on the ground that it contains an assumption; the witness has already said that he did not accept it altogether, but that he did accept certain features of it.

The Commissioner: Note the objection of counsel for the defendants.

A. That is generally true.

Q. As to the two hundred and fifteen establishments that you examined the trades wastes from in 1907 and 1908 and of which, if I recall right, you stated that one hundred and twenty-six, or sixty per cent, gave offensive trade wastes, who determined whether those trade wastes were offensive or not?

A. As soon as those two hundred and fifteen establishments were visited, or any part of them were visited, by myself or my assistants, the notes were brought to my office, and there studies and a decision arrived at, in the light of the data obtained as to the offensiveness or inoffensiveness of those trade wastes, and what portion of them was in one class and what portion was in another.

Q. How was that differentiation made as to the offensive and inoffensive trade wastes?

A. Of necessity it was made along lines which could not be set hard and fast. We naturally knew that the cooling water from a rolling mill of such wastes, would not be offensive; we knew that extremely dilute- spent dyes would not be offensive those
3644 were separated out by gathering figures from the dye masters in each establishment and from the superintendants in the various works as to how much of this dye or how much of that dye, or how much of this substance or that was used during certain periods of any day or any week, and how that particular tank or

vat was discharged, and in that way it was possible through a process of analyses of the notes to eliminate large quantities of those wastes and to include other as offensive and objectionable.

Q. Where did you get the data that you passed upon?

A. These data were obtained by inspection that, is to say inspection on the part of my assistance and myself of the tanks in which most of these wastes were stored prior to their discharge, and by conversation with the chemists and superintendents of these various works as to the manner of their discharge, and what the discharge was composed of.

Q. Then you largely depended upon the statements made at the factories themselves as to the strength of dye wastes and spent liquor trade wastes?

A. That is true.

Q. In the computation for the volume of trade wastes and sewage did you exclude the Carlton Hill Bleachery?

A. It was included in the first complete statement and was not excluded in arriving at the estimate of 11,000,000 gallons, of total trade wastes for the day.

Q. And you still regard it as in the Passaic Valley Sewerage District?

A. It comes within the limits of East Rutherford Borough therefore it is considered within the limits.

Q. In 89 of these plants that you examined I think you have stated that the volume of trade wastes was insignificant am I right?

3645 A. Yes sir.

Q. As to the character of the trade wastes, how did you find it ?

A. I could not say. If it had been regarded as important it would have been recorded because we got down as low as 400 gallons at Montclair, because of the presence of chloride of lime and copper sulphate, it is clear that these insignificant quantities of trade waste were not offensive.

Q. But you do not positively, know do you, the character of the trade wastes in those eighty-nine establishments?

A. I do not, but I did at the time the elimination was made.

Q. And you do not find it recorded in your notes there?

A. It is not recorded except as I have already stated.

Q. What other work did you do for the Passaic Valley Sewerage Commissioners during 1907 and 1908 besides this computation of the volume of the trade wastes?

A. The other work that I did in the interests of the Passaic Valley Sewerage Commissioners was to conduct an experiment in New York Harbor to ascertain the probable mixing of the sewage of the Passaic Valley District with the waters of New York Harbor. A test was run on November 19, 1907, under my direction, and for this purpose thirty thousand gallons of fresh water heavily charged with an aniline color were pumped into the Bay at rates ranging from 1.8 to 2 cubic feet per second, at low water and a depth below the surface of Ten twenty, thirty, and forty feet. At the first two

depths the dyed water rose to the surface in a short period of time and was readily discernible; discharged at a depth of thirty or forty feet no trace of the dyed water was to be found. This test was run at low water and under conditions favorable to securing
damaging proof against the feasibility of the pollution pro-
3646 ject. The discharge of this fresh water was in round number about one-eightieth of the rate of discharge such as would be anticipated in the case of six hundred thousand people.

I might call attention to the fact that similar experiments along this line were made by the Metropolitan Sewerage Commissioners and are contained on pages 457 et seq. 1910 report Metropolitan Commission, compainants' exhibit 143, to which I will refer later.

In making this test arrangements were concluded with the Merritt and Chapman Wrecking Company of New York City, whereby that Company was to furnish a pontoon containing thirty thousand gallons of fresh water, a tug boat with a necessary derrick and other appliances for towing the pontoon, a six inch centrifugal pump capable of discharging five hundred gallons per minute fifty feet below the surface water of the Bay, and a suitable quantity of six inch wrought iron discharge pipe. A launch was also provided to carry at least six persons.

On the morning of November 18th, my assistant Mr. Charles F. Breizke was sent to Saulterville where the pontoon was being filled with fresh water and at intervals during the filling twenty pounds of dye (red R) secured from Messrs. H. A. Mertz and Company, New York City, were added to the water in concentrated aqueous solution as the pontoon was being filled. A good mixture was obtained in this way; the amount of dye used was two thirds of a pound for one thousand gallons of water.

A number of preliminary tests had been made at Jerome Park Reservoir with different dyes in order to find one that when mixed in aqueous solution, in the proportions of one part of dye to 12,445 parts of fresh water, would not diffuse through salt water more
rapidly than would fresh water alone, nor stratify after mix-
3647 ing. The dye used was found to answer all the requirements and when diluted with one part in four million parts of water it imparted a bright red color to the same. The Government predictions on the day of the test indicated that low water would occur at Robbins Reef Light at twelve forty-five P. M. Observations were made by the United States Coast Survey during 1858 and 1859, (See appendix 8 pages 1 to 9, Report of the Superintendent U. S. Coast survey) showed that at the time of low water at Robbins Reef Light slack water occurred at the bottom some two or three hours before it occurred at the surface. By means of submerged floats the following notes were recorded as to direction and the approximate strength of the current at the surface and near the bottom on the day of the test above mentioned. The depth of the water was about fifty feet.

Current Observations at Robbins Reef Light.

1:00 P. M.	Surface	South	3 ft. per second
	Bottom		Strong
1:15 P. M.	Surface	"	275 ft. per second
	Bottom		Strong
1:30 P. M.	Surface	"	125 ft. per second
	Bottom		Slight
1:40 P. M.	Surface	"	100 ft. per second
	Bottom		Very slight
2:00 P. M.	Surface	"	0.75 ft. per second
2:15 P. M.	Surface	"	Slight
2:30 P. M.	"	"	Slack
2:40 P. M.	"	North	Slight
	Bottom		
3:20 P. M.	Surface	"	1.0 ft. per second
3:30 P. M.	"	"	1.0 ft. " "

3648 Four tests in all were made during which the dyed water was discharged at depths of ten, twenty, thirty and forty feet respectively, below the surface.

The results obtained were as follows:

Test No. 1. From 1:40 to 1:56 P. M. 12,000 gallons of the dyed water were pumped into the Bay and discharged at a depth of forty feet at the rate of 1.8 cubic feet per second. The field lying south of the point of discharge and approximately five eighths of a mile long and half a mile wide was thoroughly inspected with the launch for three quarters of an hour, but no trace of the dyed water could be found. The current at the surface was southward with a velocity of about — foot per second. At the bottom there was a very slight current toward the south.

Test No. 2. From 2:35 to 2:41 P. M. 5,400 gallons of dyed water were pumped into the Bay and discharged at a depth of ten feet below the surface at a rate of 2 cubic feet per second. Color was detected at the surface 20 feet from the point of discharge two minutes after beginning the color was strong, and spread out in a streak toward the north 500 feet long. The color disappeared 15 minutes after the pumping ceased.

Test No. 3. From 3:00 to 3:06 P. M. 5,000 gallons of dyed water were pumped into the Bay and discharged twenty feet below the surface at the rate of 1.9 feet per second. Color first appeared fifty feet north from the point of discharge and at about five minutes after pumping it ceased. The color was slight, covered but a small area and disappeared quickly.

Test No. 4. From 3:18 to 3:24 P. M. 5,400 Gallons of dyed water were pumped into the Bay and discharged thirty feet below the surface at the rate of two cubic feet per second. The field in
3649 the neighborhood of the pontoon was sharply watched for half an hour but no color was detected except when pumping ceased owing to the pump drawing air, when bubbles of air brought up colored water to the surface around the pipe.

The above test showed, when dyed fresh water in quantities of 5,000 to 12,000 gallons are discharged within a few minutes into slow currents of salt water having a chlorine content of about eight thousand five hundred parts per million (46% sea water), and when the discharge was from a pipe six inches in diameter at the rate of 1.8 to 2 cubic feet per second, that

1. When the point of discharge is ten feet below the surface, the fresh water rises to the op almost immediately and spreads out over a large area.

2. When the point of discharge is 20 feet below the surface the fresh water rises to the surface in about five minutes and covers only a small area.

3. When the point of discharge is thirty feet to forty feet below the surface it was impossible to detect the colored fresh water anywhere at the surface, although the average current was slight.

As it is proposed to discharge the sewage from the Passaic Valley District from multiple openings and in quantities about the same as used in the tests for opening it is expected that the resulting conditions will be similar to those of the tests.

At this point the taking of testimony on the part of the defendants was adjourned until Friday, the fourteenth day of
3650 February, at ten thirty A. M. at the offices of Messrs. Riker and Riker, Newark, New Jersey.

3651 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,

vs.

THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Offices of Messrs. Riker and Riker Newark, New Jersey, Friday, February 14th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esq., Attorney General of the State of New York;

William A. McQuaid, Esq., Deputy Attorney General;

Dr. William J. O'Sullivan, Special Counsel for The People of the State of New York, Complainants.

Edmund Wilson, Esq., Attorney General of the State of New Jersey;

Robert H. McCarter, Esq., Of Counsel for the State of New Jersey;

Adrian Riker, Esq., Of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

GEORGE A. JOHNSON resumes the stand, for further cross examination by Dr. O'Sullivan.

Q. Please continue from where you left off, yesterday.

3652 A. From these tests the inference may be drawn that fresh water sewage discharged as proposed through outlets,

some 150 in number, and located at a depth of 40 feet or more below the surface, will undergo a sufficiently complete diffusion in the waters of New York Bay so as not to raise to the surface in objectionable quantity, if at all and rarely, if at all, in visible quantities.

Among those present to witness these tests, were W. S. Ackerman, member of the Passaic Valley Sewerage Commission, Mr. Rudolph Hering, of Hering and Fuller, Mr. Wm. B. Fuller, the witness who conducted the test and his assistant, Mr. Charles F. Breitzke.

I have already referred to similar tests of this nature which have been made by the Metropolitan Sewerage Commission. The results of these experiments are recorded in the 1910 report of the Metropolitan Sewerage Commission, complainants' exhibit No. 143. The manner in which these tests were conducted and the results obtained, appear on pages 457-460. Under the heading experiments on the assent and diffusion of one liquid on another that following statements are made:

"A number of experiments were made by the Metropolitan — Commission to obtain practical information concerning the circumstances under which sewerage would and would not diffuse in harbor water. In general the method used in making these experiments were as follows: The water of sewage to be discharged was strongly colored with a dye; the discharge was then regulated to take place in a continuous stream under preagganged conditions as to velocity and volume beneath the surface of water with which it was to diffuse. The discharging current having been made visible by the dye it only remained to study the volume of diffusion by observing the colored water.

"After many tests two dyes, one known as uranine and the
3653 other special scarlet were selected; the uranine a sodium salt of flourescin was found to be particularly suitable. This dye could be detected by sight in dilutions of one to thirty million parts of water. When a bucket full of dyed sewage was thrown upon the surface of the harbor it could be seen at a distance of a quarter of a mile; it might remain visible for 20 minutes or more.

"The quantities of colored water or sewage discharged varied between 300 gallons and 56,000 gallons according to the requirements of the experiment. The harbored water varied somewhat in salinity it usually contained about 25% land water and 75% sea water. The current into which the water or sewage was discharged, varied from a little less than 1 foot per second to 3 feet per second. Most of the large scale experiments were carried on near Robbins Reef in Upper New York Bay * * * "Each experiment was carefully and fully recorded with the inferences and opinions which had seemed safe to draw from the results * * * "the experiments on the largest scale were made with boat loads of dyed water—of dyed sewage. The dyed water was contained in casks of several hundred gallons capacity. Three of these casks were located upon the Commissioners' floating laboratory and connected with a steam pump which was capable of discharging the dye through suitable holes at any required depth * * * "the total amount of experiments made was 103, of these 66 were on a large scale."

Certain of the facts and opinions drawn from the experiments are recorded in the report on page 459 and among some of those appear the following:

"Sewage when discharged into sea water rises in a mass unless intermixed through the mechanical action of current.

"When sewage is discharged through an orifice into and beneath the surface of a quiet body of water, currents are set up in the latter which help produce an intermixture between the two fluids.

3654 The force of these currents varies directly with the velocity of the discharging currents and the volume of discharge.

"Of the 66 large scale experiment about one half were successful in showing the conditions which would be avoided in discharging the sewage beneath the surface of the harbor water. In 29 cases the sewage came at once to the surface; in 31 cases no effect was visible; in 6 cases the result was doubtful. The sewage was discharged at depths var-ing between 5 and 62 feet below the surface of the water. In one case at Robbins Reef, when 600 gallons of water were discharged at a depth of 40 feet into a current of 1 foot per second, it came to the surface. In another instance when 15,600 gallons were discharged at the same place and under what seemed to be a similar condition, it did not appear at the surface."

Details of the above experiments made by the Metropolitan Sewerage Commission are not given in the report. It might in inferred that the result of the large scale experiments were favorable to the discharge of sewage from the Passaic Valley Trunk Sewer as stipulated, in view of the result of the experiment conducted by me and already referred to above.

Q. Who was present Mr. Johnson during the experiments that you describe with the red R dye?

—. Mr. Rudolph Hering, Mr. Wm. B. Fuller, Mr. William B. Ackerman, Mr. Charles F. Brietzke and myself.

Q. Were you working under the direction of Mr. Fuller and Mr. Hering at the time you conducted, in the manner in which you have testified, these experiments?

A. I hardly think you could call it that, for this reason, that this test was planned and executed under my immediate direction. They were there to observe the results. The description of the tests as previously given by me is taken almost verbatim from my report of those tests, made to Mr. Hering.

3655 —. Did Messrs. Hering and Fuller compile a report as the result of your report to them and of the other investigations made relative to the trade wastes of the Passaic Valley that were being discharged into the Passaic River?

A. They did.

Q. Was that report ever published?

A. In part.

Q. Where was it published?

A. In the report of the Passaic Valley Sewerage Commissioners, the date I have forgotten.

Q. Was it 1908?

A. 1908 yes.

Q. I show you what purports to be a report of the Passaic Valley Sewerage Commissioners to the municipalities lying in whole or in part with the Passaic Valley Sewerage district, dated 1908 and ask if that is the report in which portions of the matter that you have testified to *where* recorded?

A. It is.

Q. From the investigations conducted by yourself under the direction and with the co-operation of Messrs. Hering and Fuller were any conclusions reached relative to the discharge of the Passaic Valley sewage that were not included in this report of 1908 which I have just shown you?

Mr. Riker: Conclusions by whom Doctor?

Dr O'Sullivan: By the people I have just mentioned.

A. It is my understanding that the report you have just shown me was prepared largely by the chief engineer of the Passaic Valley Sewerage Commissioners, Mr. Edlow W. Harrison.

Q. Did Mr. Harrison pass upon what portion of the Hering and Fuller report should be included in the report of the Passaic Valley Sewerage Commissioners dated 1908?

3656 A. That I do not know.

Q. Have you got the full report of Messrs. Hering and Fuller on the conditions relating to the discharge of sewage or the condition in which the sewage would reach the pumping station at or near the Newark meadows?

A. I have what I believe to be a copy of the report of Messrs. Hering and Fuller to the Passaic Valley Sewerage Commissioners, dated December 31, 1907, which report pays particular attention to construction features and features of design and cost of operation and maintainance of the proposed project and among the appendices I find a digest of the report prepared by me on the trade wastes investigation and on the composition of the sewage of the Passaic Valley District; also a practically complete copy of my report to Mr. Hering on the test before referred to, of dispersion of dyed fresh water in New York Bay. In this report I find no predictions as to the probable compositions of the sewage of the district as discharged below Newark.

Q. Do you find in that report of Hering and Fuller any conclusions from such investigations as were made to the condition in which the sewage would reach the pumping station?

A. I find no statement in this report bearing on that phase of the matter.

Q. Did they reach any conclusions which you knew, of relative to the condition in which the sewage would reach the pumping station?

Mr. Riker: The question is objected to on the ground that it is irrelevant and immaterial, and if the conclusions are relative to the inquiry they should be proved in another way.

The Commissioner: Note the objection of counsel for the defendants.

A. It is my belief that such conditions were formed as the result

of many conferences between the various members and em-
3657 ployees of the firm of Hering and Fuller; but these conditions were not set down in the report as they were considered to be immaterial.

Q. Did you reach any conclusions yourself from your observations of such work as you did to determine the character of the sewage as to what the composition of the sewage would be when it reached the pumping station?

A. I have already testified as to my conclusion on that line.

Q. In what condition did you expect it to reach the pumping station?

A. My conclusion in general with regard to the probable composition of the sewage discharged by the Passaic Valley Trunk Sewer at the treatment works below Newark, were as follows: That the sewage will probably not, as a rule, contain large volumes of offensive odors. It may at times be devoid of dissolved oxygen, but for most of the time would probably contain a small amount of dissolved oxygen. The reason which I have previously given in my testimony, are that the rapid velocity of flow of the sewage in the trunk sewer, and with the sewers contributing sewage to the main trunk sewer, which contributing sewage will, much of the time, contain material quantities of dissolved oxygen, and because of the infiltration of ground water into the trunk sewer which ground water will contain material quantities of dissolved oxygen, the sewage as discharged below Newark will not have been afforded favorable opportunity to become septic as would be the case if it were devoid of dissolved oxygen throughout practically the entire length of the trunk sewer, and if the velocity in the trunk sewer were sufficiently low to allow of the deposit therein of quantities of suspended organic matters which would later undergo *putrifaction* through agencies of bacterial activities?

3658 Q. When did you reach that conclusion, what year?

A. In general it has been my belief from the beginning.

Q. Dating from when?

A. 1907.

Q. Did you express that opinion to Messrs. Hering and Fuller in 1907?

Mr. Riker: The question is objected to on the ground that if conversation is the proper subject of an inquiry the witness should be appraised of the time and place and the general character of the conversation.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: Complainants' counsel presses the question because this is not relative to a conversation but a report made by an employee to his superiors and in relation to the subject matter of a report made by them to the Passaic Valley Sewerage Commissioners which this witness has testified was never published excepting in part.

Mr. Riker: The question is now objected to on the statement of counsel concerning the question on the ground that such a question

is only admissible for the purpose of contradiction of this witness and is not proper in form for that purpose.

The Commissioner: Note the further objection of counsel for the defendant.

A. I think that, in general, I did.

Q. Was that embodied in a conclusion reached in the report of December 31st, 1907, by Messrs. Hering and Fuller and submitted to the Passaic Valley Sewerage Commissioners?

A. It was not, as before stated.

3659 Q. Will you look at the report which you have stated you believe is a copy of the report of Messrs. Hering and Fuller dated, December 31, 1907, and see if you find the conclusions that I will now read to you in that report:

"The indications are under present conditions that the sewage as it reaches the pumping station on Newark meadows will normally be devoid of dissolved oxygen. From the foregoing result it seems quite plain that even though the discharge of the several outlets contribute considerable dissolved oxygen, this will be quite speedily absorbed. In its travel of 20 miles in some ten hours it will become septic, but the more or less constant addition along the route of sewage containing dissolved oxygen will retard rapid putrifaction. As received at the pumping station, the sewage will doubtless be septic and blackened."

Q. Will you see if you can find what I have just read to you now as the conclusions of Messrs. Hering and Fuller and which was not included in the Passaic Valley Sewerage Commissioners' report of 1908?

Mr. Riker: The question is objected to as immaterial and irrelevant to this inquiry and on the further ground that the original report, if it is desired to have testimony from it, should be called for and produced and proved in regular course.

The Commissioner: Note the objection of counsel for the defendant.

A. No such statement appears in my copy of what I believe to be the report of Hering and Fuller to the Passaic Valley Sewerage Commissioners, dated December 31, 1907.

Q. Have you got the complete report there, Mr. Johnson?

A. I have yes, sir.

Q. Will you permit me to offer it in evidence as the complete report?

3660 Mr. Riker: You will not offer it in evidence with my consent; if you want the report call for it.

Q. You are quite positive that you have the full report there of Hering and Fuller of December 31, 1907?

A. This report is marked on the cover "extra copy"; it has the typical binder used in the office of Hering and Fuller at the time I was connected with that firm; it is addressed to The Passaic Valley Sewerage Commissioners Prudential Bldg., Newark, N. J. and is dated December 31, 1907.

Q. How many pages are there in the copy you are consulting and testifying from now, Mr. Johnson?

A. The report proper is of 37 pages; there are 5 appendices, making the total number of pages 72.

Q. In 1907 how long was it estimated that sewage would take to reach the pumping station from Paterson?

Mr. Riker: The question is objected to on the ground that it does not appear whose estimate is called for by the question.

The Commissioner: Note the objection of counsel for the defendants.

A. I presume somewhere in this report there are data from which the time you refer to could be determined; I am unable to put my hand on it now, but I find on page 66 of this report the approximate distance from the West 18th St. outfall at Paterson, which each contributing sewer along the line of the trunk sewer is from the point mentioned. No reference is made to the velocity of flow in this sewer, in this table, so I am unable to answer your question more definitely.

Q. Will you permit me to look, Mr. Johnson?

Mr. Riker: There is no reason why you should Mr. Johnson. I recommend that you do not.

Q. What is your answer to my question?

A. On the advice of counsel I must refuse.

3661 Mr. Riker: Counsel for the defendant says that if counsel for the complainant desires to call for the original report, it will be produced, if we have it.

Dr. O'Sullivan: I make such a request, that the original report be produced.

Mr. Riker: Very well, we will see that you shall have it. This is not the original; at a later — I will examine the records of the Commission and find if they have the original report there.

Q. Is it your opinion that you have an exact copy of the original report in front of you now?

A. I am led to believe so because of the peculiar manner in which it is bound. But I have no knowledge of its being a precisely correct copy.

Q. Have you any reason to believe that any pages are missing from the report, from the copy which you now have in front of you, are there any pages missing, that you know of?

A. It is difficult for me to say for the reason that it is irregularly paged and not consecutively paged, each section and each appendix being paged by itself; furthermore none of the tables are paged.

Q. Who first suggested the dye tests and the particular dye that was used in experiments you have described?

A. I am unable to say, but the dye selected for the tests was my choice.

Q. Why did you choose red R as dye for these experiments?

A. I chose it after making careful studies of the power of diffusion of various dyes of this same general character.

These tests were made at the Jerome Park Reservoir Station, in 1907, in November, I think.

Q. What other dyes have you ever experimented with?

3662 A. In what manner?

Q. On these diffusion tests, any where at any time?

A. I could not say precisely but probably about half a dozen.

Q. Will you name them?

A. I cannot off hand. They all were obtained from the same source, H. A. Mertz and Company of New York City, and were all either red or yellow dyes.

Q. When you mentioned uranine special scarlet and flouresci and red R dye, did you ever work with any of those other dyes besides the red R dye which I have just mentioned?

A. As before stated I tested put several dyes at the Jerome Park Reservoir Station in 1907 and selected this one as giving the highest color in the greatest dilutions and as being a dye which diffused through a body of salt water no more rapidly than did fresh water itself?

Q. The experiments you conducted with this dye at the Jerome Park Reservoir, were in fresh water were they not?

A. Salt water.

Q. At the Jerome Park Reservoir?

A. At the station on Jerome Avenue.

Q. What is the chemical composition of red R dye?

A. I could not tell you.

Q. How is it effected by nitrites?

A. In such quantities as would be encountered in fresh water, or in salt water for that matter, I should think it would have practically no effect.

Q. What percentage of nitrite occurs in sea water normally? Can you answer my question without consulting a work on chemistry?

A. I am not consulting a work on chemistry, I am endeavoring to get a published analyses of sea water, I presume, that is

3663 what you want. The contents of sea water in nitrites and in nitrates, as a matter of fact in all constituents, will vary with the composition of that particular sea water.

Q. Taking the Atlantic ocean sea water two miles from the shore?

Mr. Riker: The question is objected to on the ground that it does not appear that this witness has examined that water taken from the point mentioned, and the question has no foundation whatever.

The Commissioner: Note the objection of counsel for the defendant-.

A. I could not tell without consulting, (interrupted).

Q. How do carbonates in salt water affect red R dye in aqueous fresh water solution?

A. I have no knowledge.

Q. How will the sulphates in salt water affect red R dye in fresh water solution?

A. That I don't know.

Q. How will the putrifactive gases that are evolved from an-erobic decompositions of sludge deposits on the harbor bottom, affect red R dye when in its immediate vicinity?

A. I have no knowledge on that point.

Q. Do you know what the chemical composition of fluorescim is?

A. I have already read in into the testimony, I do not know personally, no.

Q. Do you know what the chemical composition of special scarlet or uranine is?

A. I do not.

Q. Do you know whether they are affected by the bleaching action of the components evolved from pollution and putrifactive agents in brackish water?

3664 A. Inferrentially I should say no, for the reason that these dyes are always used in such tests as these and in attempting to trace polluted matter from a known source of pollution to running streams or other bodies of water.

Q. In the tests which you describe with the red R dye you found coloration of the water where the injection into the current was at only a few feet from the surface; is that right?

A. Down to a depth of 20 feet below the surface, according to our experiments, these heavily dyed fresh waters were observed to rise to the surface; below that depth they could not be detected.

Q. Is an an-erobic action most active below or above the 20 feet depth, you preformed the experiment in, where you discovered the discoloration of the harbor water?

A. It appears perfectly clear to me that an an-erobic action is restricted almost entirely to the deposits on the harbor bottom and that in the overlying strata of water no such actions are going on.

Q. What is the oxygen contents in the 2 or 3 feet of water overlying these harbor deposits?

A. From such knowledge as I have of work which has been done on this point, I assume, basing my assumption very largely on the findings of the Metropolitan Sewerage Commission, that, excepting at the bottom of the harbor there is very little difference in the oxygen contents of the overlying waters at any depth, which explains in a large measure the reason for my last answer.

Q. What are the products of an-erobic decomposition evolved from these harbor deposits?

A. I believe that they are legion; among others may be mentioned iron sulphate, sulphuretted hydrogen, marsh gas, etc.

3665 Q. How will hydrogen sulphite affect red R dye when in solution in fresh water?

A. I have already stated I have no knowledge on this point but in view of what I have already testified to with regard to an-erobic action being confined to the bottom layer, as a normal proposition, I do not believe that hydrogen sulphide is present in the overlying strata of water in quantities sufficient to affect the color of the red R dye, referring particularly to its oxidizibility, although I have no positive evidence on this point.

Q. What volume of hydrogen sulphide is necessary to bleach red R dye?

A. I don't know.

Q. Or interfere with its color in any way?

A. I don't know.

Q. Have you made any tests to determine the quantity and *solubilinity* of hydrogen sulphide in brackish waters?

A. No sir.

Q. How will methane affect red R dye when in fresh water solution meeting it in the presence of brackish water?

A. I don't know.

Q. Do you know whether nitrogen and hydrogen, these gases, are given off in brackish water as the product of an-erobic decomposition?

A. I presume there is little question of that; I think such is the case.

Q. Do you know whether the element sulphur itself is evolved from sulphuric oxide as the product of an-erobic decomposition?

A. It is undoubtedly evolved.

Q. And that is a strong bleaching agent is it not?

A. I presume as such it is, without having first gone into combination with some other substance or gas.

3666 Q. And you have conducted no experiment to determine these factors that at great depth might interfere with the result of your experimental works in that particular which you have testified to?

A. No sir.

Q. What was the depth of the experiment in which you failed to discover color?

A. The two depths below 30 feet.

Q. Which was the deepest?

A. 40 feet.

Q. How near to the deposits from the mouth of the 6 inch pipe through which you discharged the red R watery solution?

Mr. Riker: The question is objected to on the ground that it does not appear in the evidence of this witness or elsewhere that there were any deposits nor what the deposits were.

The Commissioner: Note the objection of counsel for the defendants.

A. The total depth of water at the point where the tests were conducted was between 60 and 70 feet; the distance from the bottom of the harbor to the mouth of the discharge pipe during the tests where the dyed water was discharged at the lowest depths beneath the surface was therefore between 20 and 40 feet.

Q. How deep, was the water at the sides of the channel where that great depth exists?

A. I would not attempt to say in precise terms, but it ranges from a maximum depth of the channel at that point, according to my best recollection, of 70 feet, to about 25 feet or less, on the submerged banks of the channel?

Q. In which direction did the six inch pipe through which you made the discharge, point?

A. Vertically downward.

Q. Did it face either to the north, south, east or west?

3667 A. It did not.

Q. How near to either bank of the channel were you when you made the discharge?

A. The point of discharge was near the western edge of the main channel and about ⅝ of a mile northeast of Robbins Reef light.

Q. How did you determine the location of the boat?

A. We gave directions to the captain of the tug boat to anchor the pontoon at that point, and when we went out to the pontoon we observed that it was about in the location*d* mentioned. No precise determinations were made to absolutely fix the exact point.

Q. Do you mean to tell me Mr. Johnson that the boats you were operating in with these experiments were anchored in the main ship channel?

A. Just off it.

Q. How far off of it, that is what I am trying to get at?

A. The tug boat itself was anchored on the bank of the channel; the pontoon was suspended out over it.

Q. How near to the bank and how far from the boat in which you were conducting these experiments?

A. The pontoon was attached to the tug boat, therefore the location would be near the edge of the channel.

Q. How near?

A. I could nor say beyond what I have already stated that it was near the edge of the channel.

Q. Within a few feet?

A. Within a few feet.

Q. And the edges of the channel are largely composed of these sewage deposits are they not?

A. I am not in a position to state of my own knowledge.

Q. Did you think it material to take that fact into con-

3668 sideration in conducting these experiments?

A. There were so many data on record in the reports of the Metropolitan Sewerage Commission, that we felt inclined to take their data as being true statements of the facts.

Q. Would any of their data enable you to locate a boat at a fixed point in the channel, or on the banks of the channel in upper New York Bay?

A. I presume there may be such data in their reports, but I do not recall any such at this time.

Q. How did they make their locations, for harbor points that they would plot on maps as scenes or sites for experimental work?

A. I presume those facts are stated in their reports, I don't know.

Q. How would you make a location in New York Upper harbor so as *as* to identify it later on a map?

Mr. Riker: The question is objected to on the ground that the witness is not an expert, and does not profess to be, on surveying

and that it is immaterial and irrelevant how he would do it, the only possible relevant question being what was actually done.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: The question is pressed by complainants' counsel because the witness has stated that he depended upon the mariner who located the boat *the boat* on the edge of the ship channel.

Mr. Riker: I do not understand the witness has said that; he has stated the condition of things, but not as counsel for the *defendant* has stated.

3669 A. The only attempts that were made to establish the approximate points at which these experiments were made were as already stated; we made a trip in a launch from the tug boat around or near the Robbins Reef light, observed it from all points and it was the concensus of opinion on the part of those present that this location was approximately as stated in the previous testimony. We made such soundings as satisfied us as to the depth of the water at this point and at points relatively near it.

Q. Who made the soundings?

A. Mr. Brietzke and myself.

Q. Have you recorded those soundings in the reports you made of those experiments?

A. I have not in this testimony.

Q. Are you depending on your memory now for the facts relating to the soundings?

A. Yes sir.

Q. What is the depth of water at Robbins Reef Light itself?

A. I never determined it.

Q. What is the depth of water within a quarter of a mile at Robbins Reef Light in either direction away from the channel?

A. If you desire those data I can obtain them for you in a few moments from authenticated records.

Q. Have you recorded the soundings in the report you made?

A. I think not. Those soundings were made incidental to the collection of certain samples of water at various depths at the time these experiments were going forward.

Q. Were all the tests that you have testified to made at the same point?

A. With the exception of such tests as we made at Jerome Park.

Q. Those in reference to the red R dye tests, were the tests made at the same point?

3670 A. As I have said, with the exception of such experiments on this same point as were carried on at Jerome Park.

Q. Those conducted at the harbor were at the same point?

A. They were.

Q. What was the condition of the tide?

A. Between the hours of 1:00 P. M. and 3:30 P. M. and it was during this period that the tests — made. The tide was flowing south, between the hours of 1:00 P. M. and 2:30 P. M. turning north at

the surface at 2:40 P. M. and continuing in that direction throughout the test.

Q. The flood began when?

A. It was notic-able at the surface at 2:40 P. M.

Q. How long did slack water last before the turn of the tide on that day?

A. At 2:15 P. M. the current at the surface was slight, in a southerly direction; at 2:30 P. M. the current was slack at the surface; at 2:40 P. M. the current was slightly in a northerly direction.

Q. At what hour did you make that deeper experiment?

A. At 3:18 to 3:24 test No. 4 was made and in this case the dyed water was discharged at a depth of 30 feet below the surface.

Q. What was the condition of the tide at that time—3:18 I think you said until 3:30?

A. It was in flood at the surface.

Q. How far did you go from where you discharged the colored dyes to seek its re-appearance?

A. About a mile.

Q. In what direction?

A. In the direction of the tide and—in both directions as a matter of fact. We scoured the field in all points radiating from the pontoon, the point of discharge.

Q. And that was at 3:30?

3671 A. Yes, sir.

Q. And you had flood at what time?

A. The tide turned north at 2:40 P. M. as I observed it at the surface.

Q. When you began these experiments you began on the ebb tide at 1:30?

A. That is right.

Q. Do you know anything about the phenomena of the undercurrent at that time in the main ship channel in New York's upper bay?

A. I do not, in precise terms of velocity in feet per second; we were, however, taking samples of water at different depths during all this period at various times and in this manner were able to ascertain whether the tide was strong at the bottom or otherwise. That has been recorded in my previous testimony in the form of a table headed: "Current observations at Robbins Reef Light."

Q. As to the current that obtained between 1:30 and 3:30 P. M. were there not two bodies of water moving in opposition directions just where you were experimenting?

A. That would be expected in view — observations that have repeatedly been made by the government officials and by the Metropolitan Sewerage Commission, but in this case I am unable to cast any definite light on that point for the reason that we merely recorded the intensity of the current at the bottom as "strong" or "slight" or "very slight" or "slack."

Q. What is the average velocity of the ebb in Upper New York Bay?

A. The data are somewhat conflicting on this point, but I can

refer you to observations made by the United States Coast Survey, to the report of the superintendent, dated 1873, page 129, in which the velocities of the tides off Robbins Reef are given as
3672 follows:

Velocities in Feet Per Second.

Point.	Tide.	Max.	Min.	Average.
Surface	Flood	0.54	0.10	0.35
	Ebb	2.13	0.82	1.36
12 feet below	Flood	1.68	0.64	1.08
	Ebb	2.57	0.54	1.67
48 feet below	Flood	2.26	0.13	1.25
	Ebb	0.69	0.20	0.53
Average	Flood	1.49	0.29	
	Ebb	1.80	0.52	

On page 155 of the 1910 report of the Metropolitan Sewerage Commission, those average velocities of flow on the ebb and the flood tide are given as follows——

Q. (Interrupting.) Before you give that I would like to ask you if the currents in any way changed in the main ship channel between 1907 and 1910, the dates concerning which you are about to read?

A. That is precisely the point I am coming to, Doctor.

It is observed here that the maximum velocity of the flow of the current on the ebb tide is 3.42 feet per second and on the flood tide 1.27 feet per second; mean velocities of flow of the current on the ebb tide are given as 2.07 feet per second and on the flood 1.61 feet per second. These last given data show figures even higher than the velocities observed by the government as previously recorded, so in answer to your question, it may be inferred that the
3673 velocities of the current near Robbins Reef have increased since 1873.

Q. The government velocities that you have just read were for what year?

A. I am unable to state that; there is merely recorded the fact that these observations were made by the United States Coast Survey and they are recorded in the report of the superintendent dated May 1873 (page 129) and presumable were made during the year 1872-3.

Q. Do you know whether or not the current velocities have been changed considerably between 1892 and 1907 when you made your observations, by any factors?

A. Not to my knowledge, no, sir.

Q. What is the distance from the Battery to Sandy Hook?

A. I can't say without measursing it.

Q. Will you say that the ebb currents in 1907 were more than a quarter of a mile per hour?

A. Yes, I should say they were considerably more than that.

Q. Have you, in the course of your investigation, consulted a

report by Colonel Black in 1909—William M. Black, Colonel Corps Engineers, chief engineers, office Department of the East, to the Adjutant General Department of the East at Governors Island, New York on June 1, 1909?

A. I saw the report when it came out and have a copy of it; I have consulted it to some extent.

Q. Colonel Black in that report, in the 11th paragraph, gives the distance between the Battery and Sandy Hook as 16½ miles, and I quote his words now:—

"The mean velocity of the ebb current is about ¼ miles per hour."

Q. Have you reason to doubt that?

A. The observations made by the Metropolitan Sewerage Commission referred to, indicate an average velocity of flow of the
3674 tidal stream of about 1¼ miles per hour.

Q. For what year was that?

A. I presume those were observations of 1909 for the reason that these data appear in the report of the Metropolitan Sewerage Commission (page 155) for 1910.

Q. Had anything occurred between 1907 and 1910 to either increase or diminish the current velocities that you know of?

A. I presume you refer to the dredging operations; it is possible that they may have to some extent affected the velocity.

Q. How did the opening of the Ambrose channel affect the velocities in the main ship channel if you know?

A. It is to be inferred that they would be liable to reduce these velocities but not to any material extent that would allow of the statement that the average velocity of the flow is ¼ of a mile per hour, in the face of the data given by the Metropolitan Sewerage Commission, above referred to, where the velocities are shown to average 1¼ miler per hour. The difference is to- great to be accounted for in this manner.

Q. How does the Ambrose channel intersect the main ship channel in the upper Bay?

A. I could not tell you.

Q. Does it intersect it in Upper New York Bay?

A. I know nothing about it.

Q. What was the duration of the ebb flow, the average duration of the ebb flow in 1907, 1908 or 1909?

A. I don't know but I presume it was 6¼ hours, that is the usual period of either tide.

Q. That being so, why did you go north after you conducted that deep water experiment at 3:18 P. M.?

A. We made it a point not to leave any possibility uncovered therefore we went to improbable places as well as those we considered probable.

Q. Was that 6¼ hours from 1:30 P. M. when the ebb began?

3675 A. Every ebb and every flood tide is supposed to be 6¼ hours in duration.

Q. And in this particular instance you had flood in less than that time, did you not?

A. We did not cover the full tide.

Q. What I want to know is, after making your injection during the ebb, why you went north to see if the color appeared on the surface?

A. We covered an hour and a half of one ebb tide, and about an hour of a flood tide. We therefore had no knowledge of the precise nature of the velocity of flow of the underlying strata. We wanted to be sure that we did not miss it, if it happened to be carried north by some other current.

Q. Did you make any attempt to determine the velocity of the bottom current on that occasion?

A. Nothing further than observing the direction in which the cord holding a sample bottle was thrown off the perpendicular, and observing the intensity of the pull on the cord.

Q. Do you know whether that had gone down deep enough to reach the under-run?

A. We know it went down 60 or 70 feet.

Q. Did you know how deep the under current was operating?

A. No.

Q. So that the dye may have been carried in a direction different than the one in which you looked for it?

A. If it did and reached the surface, it reached it outside of a radius of a mile from the point of discharge, because we were passing over that territory as fast as a light launch with a high power engine, could carry us.

Q. I understood you went north after you made the injection of this colored fluid?

Mr. Riker: The question is objected to on the ground that there is involved in the question a statement by counsel that does
3676 not accord with the witness's testimony; he stated they went in every direction.

The Commissioner: Note the objection of counsel for the defendants.

A. I can only repeat that we covered the entire field, north, south, east and all directions.

Q. And in what period of time?

A. We were constantly in the launch, coming back at the time when each experiment was started and starting a new one.

Q. If that injected color fluid had been injected into the under-run where would you expect to find it on an ebb current?

A. We didn't expect to find it.

Q. In what direction did you look for it?

A. In all directions.

Q. Did you travel in a circle or at various right angles to the point where you made the injection?

A. We did not lay those lines out with extreme precision.

Q. If it had been injected into the under-run where would you expect it to arise and appear on the surface?

A. That would entirely depend on the depth at which it was dis-

charged, the velocity of the current and the other features intimately related to that general phase of the problem.

Q. If it were injected into the under-run might it not reach the Battery before it came to the surface?

A. I could not tell.

Q. Did you go as far as the Battery to look for it?

A. I think not; we might have if it was within the radius of a mile.

Q. Do you remember now whether you did or did not go as far as the Battery?

A. I think we did not.

3677 Q. You mentioned something yesterday about submerged floats how were they constructed?

A. I do not recall where that testimony appeared, but I do remember the statement was made, I find it now. Those floats were used by the United States Coast Survey and are referred to in connection to the observations made by that survey during 1858 and 1859 and are recorded in appendix 8, pages 1 to 9, report of the Superintendent U. S. Coast Survey.

Q. Did you use any submerged floats on the occasion when you made these experiments with the red R dye?

A. We used no floats with the exception of the sample bottles to which I have already referred.

Q. Who put the red R dye in the water that was used for the experiment?

A. Mr. Charles S. Breitzke.

Q. Did you see him do it?

A. No sir.

Q. Do you know what the strength of the solution of this red R dye is?

A. I have known Mr. Breitzke for a great many years and I have always observed that he followed instructions. I purchased the dye myself and gave it to him; it was not exceedingly valuable but I don't believe he would have thrown it away; I saw the dyed water after he had prepared it, in the pontoon, as did Mr. Hering and Mr. Fuller, and I am satisfied that it was of the strength mentioned. It had the color of blood.

Q. But you did not see the mixture you said until after it was in the pontoon?

A. No sir, that has already been recorded in the testimony.

Q. Do you think the experiments you performed are in any way comparable with the continuous discharge of sewage from such a large outlet, or series of outlets, as is contemplated in the Passaic Valley Sewerage project?

3678 A. I do.

Q. The large experiment was with 500 gallons per minute, that was the rate, was it not?

A. I believe that was the figure.

Q. And that would equal how many gallons in twenty-four hours?

A. 720,000.

Q. What is the full or maximum capacity of the proposed discharge from the Passaic Valley Sewage?

A. I have not looked into that actively for some years, but I believe it is designed to care for an ultimate average sewer flow of 240,000,000 and a maximum flow of 360,000,000 gallons per day.

Q. Apart from the oxygen determination made of the sewage and these experiments and the mode of examining the trade wastes that you have described, what other work did you do in relation to the Passaic Valley Trunk Sewer project?

A. I spent several weeks at the Jerome Park Station making determinations in order to cast some light on the rapidity and completeness with which fresh water, charged with fine clay, water colored with aniline dyes, and fresh water alone, would mix with salt water. These tests were carried on in the latter part of 1907.

Q. Where is the Jerome Park Reservoir Station that you mentioned?

A. At the southern end of the existing Jerome Park Reservoir.

Q. In New York?

A. In New York City, yes sir.

Q. Did you hold any official relations with the municipality of New York at that time?

A. My firm were consulting engineers to the Department of Water, Gas and Electricity at that time, or had been a short time
3679 prior to that. These experiments, however, were carried on with devices owned by people other than officials of New York or citizens of New York.

Q. What other work did you do besides the experimental work you have just now alluded to?

A. I paid particular attention to various other phases among the more important of which might be mentioned the possible feasibility of purification of the sewage of the Passaic Valley district before its discharge.

Q. Did you make any chemical analyses?

A. No sir.

Q. Or bacteriological analyses of any kind?

A. Not that I remember.

Q. Or microscopical examination?

A. Not that I recall.

Q. What other work did you do in 1907 or since then in relation to the Passaic Valley Sewerage Commission's project for a trunk sewer?

A. I think I have mentioned all of the work that I did.

Q. I think in your direct testimony you stated that you had been recently active in examining some of the data submitted to you in relation to this trunk sewer project, am I right?

A. Yes sir you are in reference to the examination of the plans which are proposed for the treatment of the sewage of the district.

Q. Did you see all the plans and specifications of the Passaic Valley Trunk Sewerage Commissioners?

A. It is difficult for me to answer that because the plans are legion; I saw a great many.

Q. Who submitted them for your inspection or study?
A. Mr. William Gaven Taylor, principal assistant engineer.
Q. When had you see- the plans previous to that?
A. All of the plans that I had seen prior to that time were
3680 those prepared in the office of Hering and Fuller at the time I was connected with that firm.
Q. When did you see them there last, before severing your connection with that firm?
A. I saw them practically every time I opened the wrong drawer until I left the office.
Q. Were any changes made in those plans between 1907 and 1908 and the time of your seeing them now in the month of February 1913?
A. I presume there have been many changes made, there always are in any set of plans.
Q. Do you know whether there were or not?
A. No sir.
Q. Do you know whether there were very material changes made as to the caliber of the trunk sewer itself?
A. I am not positive.
Q. What is the length of the trunk sewer proposed to be?
A. To the best of my knowledge it is some twenty miles long at Newark; between Newark and the point of discharge the distance is some five or six miles.
Q. What is the average diameter of the intercepting sewer?
A. As now designed I am unable to state.
Q. I understand you saw those recent plans in this present month?
A. Yes sir, I did.
Q. The plans executed by Mr. Edlow Harrison and Mr. Taylor and completed in December 1910.
A. I believe that was the set I saw with some additions.
Q. What is the maximum capacity of the trunk sewer itself?
A. That I do not know, beyond what I have already testified to, that it was my understanding the capacity of the main trunk sewer was 360,000,000 gallons per day.
3681 Q. How many communities is it proposed to serve or is the sewer designed to serve?
A. At that time there were some twenty odd.
Q. Covering what drainage area?
A. I am unable to say.
Q. How many of the communities to be served by the Passaic Valley Sewer project are sewered on the combined system?

Mr. Riker: Question objected to because it does not yet appear that this witness even knows how many communities are to be served by the joint sewer and the question is immaterial and irrelevant.

A. I do not know the precise number there are quite a number.
Q. Is that an important item to know in passing upon the efficiency of the project?

Mr. Riker: The question is objected to on the ground that the

efficiency of the project is not an issue in this case and the question is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. Why, yes it is an important feature especially becoming so at time of storms and thaws.

Q. Do you know what the precipitation is at the Passaic Valley water shed that will be drained by this trunk sewer scheme?

A. Not knowing the area of the shed I could not say.

Q. Is the trunk sewer scheme designed for the dry weather flow, or for the dry weather and storm flow?

Mr. Riker: I enter the same objection as made last.

The Commissioner: Note the objection of counsel for the defendants.

A. It is my understanding that it is designed for maximum flow at any time.

3682 Q. Of both or either, which?

A. Both.

Q. From your study of the Passaic Valley Trunk sewer project would you say that it is designed to take storm water as well as dry weather flow and sewage?

Mr. Riker: The question is objected to on the ground that it is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. I could not state explicitly but I should presume it was designed to take both the sanitary sewage, or the so-called domestic sewage, the trade wastes, up to a volume equivalent to ten per cent of the total volume and such storm flow as would be encountered at time of rain storms. I do not know whether the expedient has been adopted of building into the trunk sewers storm overflows, or into the lateral sewers, but I should suppose that would be the case.

Q. Do you know whether or not it is the case in the present plans of the Passaic Valley Sewerage Commissioners for this trunk sewer?

Mr. Riker: The question is objected to because the witness has just immediately testified before the question was put that he did not know.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: The question is pressed for the reason that this witness has also testified that he examined the plans in the present month.

A. That is something I do not know, and, further, I would like to state that I was particularly interested in my examination of these plans in the features relating to the treatment of the sewage and to the manner of its discharge in New York Bay.

3683 Q. Is its volume not an important item in considering the treatment it is to be subjected to?

A. It is but I have used the assumptions upon which the design of the sewer was based, namely, in 1940, of thereabouts, the total population to be provided for would be in the neighborhood of 1,600,000 people; aside from the number of people sewering into the sewers, I have no cause to be interested in what the probably flow of the sewer may be, in as much as I am attempting to draw my inferences and conclusions on the amount of matter which is to be discharged by the population and not on the volume of sewage contributed by them.

Q. What is the volume of sewage to be contributed by the City of Paterson?

A. Throughout our studies of this question in 1907 it was assumed that the domestic sewage flow would be 150 gallons per capita per day. Not knowing the exact population of Paterson at this time I am unable to state what the sewage flow from that city is, but I presume it to be in the neighborhood of 20,000,000 gallons.

Q. How do you estimate the sewage per capita share for Paterson?

A. That is only done in a precise manner by taking the water consumption and gauging the various sewers carrying off the wastes of a particular district.

Q. How do you get the water consumption?

A. By meters.

Q. Is there no water consumed in Paterson that does not come from the public water supply that is metered?

A. I think not. There is, however, a great deal of water used in Paterson around the lower districts, where the mills are located that comes from other sources than the public supply, the bulk of that water being used for power purposes and for the treat-
3684 ment of goods in these mills and it finds its way back into the river and will continue to do so to a large extent.

Q. Carrying the trade wastes with it?

A. Carrying the inoffensive trade wastes with it and at the present time much of the offensive trade wastes.

Q. What percentage of the trade wastes of Paterson is it computed will be carried in this trunk sewer project?

A. I have always supposed that the proper interpretation of that clause of the act refer-ed to the total percentage and not to the individual percentage of any community.

Q. What is the total percentage of trade wastes to be carried in the Passaic Valley trunk sewer project?

A. I understand it to be ten per cent of the total sewage flow.

Q. What is the total trade wastes of the region to be served by the trunk sewer project?

A. In 1907, and eliminating from consideration at this time those districts which are to be withdrawn, the average trade wastes flow amounted, according to my estimates, to about 10,000,000 or 11,000,000 gallons per day.

Q. How do you separate the ten per cent of a given factory from the 90 per cent they are forbidden to convey into the trunk sewer?

A. That is not a simple problem, but it can be affected by co-operation with the superintendent of the mills to a large degree. If at the present time, with a population of 800,000 people, the trade wastes amount to some 12,000,000 gallons, the completed project with one million six hundred thousand people will give an amount of trade wastes well within the ten per cent limit, because the volume of trade wastes will not increase in proportion to the sewage flow in the future.

Q. Where does the ninety per cent of the trade wastes go that are not gathered in the trunk sewer?

3685 A. I think that is rather an ambiguous question, Doctor, because there is nowhere stated the fact that 10% of the total wastes shall be discharged into the sewer and 90% be discharged into the river or otherwise disposed of.

Q. Then 10% goes into the trunk sewer and 90% of the trade wastes will be discharged into the river?

Mr. Riker: The question is objected to, if it is a question, on the ground that it is a statement of counsel, of a fact not testified to, which, as a matter of fact, is not true.

The Commissioner: Note the objection of counsel for the defendants.

Q. Has any provision been made for the disposal of 90% of the trade wastes of the Passaic Valley Sewerage District that you know of?

A. The matter has never been considered for the reason that in my opinion your assumption is based on conditions which do not and will not exist. The trade wastes phase of the question is, limited to the statement that of the total volume of flow the total volume of trade wastes shall constitute but 10% of the whole volume of sewage.

Q. Have you at no time been aware of what provision was made for the 90% that was left, after abstracting the 10% of trade wastes?

Mr. Riker: The question is objected to on the ground that it assumes as a fact that there will be 90% trade waste left and it does not appear anywhere that such fact exists.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not now consider, nor have I during my investigation of this problem that the percentage of offensive trade wastes will be in excess of 10% of the total volume of trade wastes.

3686 Q. What per cent will they be?

A. I am unable to say.

Q. Of what character will the 90% of the trade wastes be?

A. Undoubtedly some of the 90% will be offensive and be included in the total of 10% of the total volume of sewage which is allowable.

Q. Taking the trade wastes at the original 100% what provision has been made by the Passaic Valley Sewerage Commissioners for separating out 10% of that trade waste?

A. That provision is clearly stated in the Act, that of the total flow of the Passaic Valley District the trade wastes shall not amount to more than 10% of the total volume flow in the sewer.

Q. So that to determine how much trade wastes shall be admitted to the trunk sewer, you have first to determine the amount of domestic sewage that is to be carried and then estimate 10% of that, is that the idea?

A. I should think you would begin at the other end.

Q. I am seeking light. Answer so as to set me right on that?

A. I would arrive at that answer by determining in the first place the volume of trade wastes which would be contributed to the sewer, as was done in the study of 1907; that investigation showed a total of 12,878,000 gallons of offensive trade wastes contributed by about 600,000 people; a similar conclusion could be arrived at when the population reaches 1,600,000 total, or when the project is complete, so as to guard against excess.

Q. How was that estimate ma le?

A. The estimate I have referred to?

Q. Yes.

A. I have testified at length on this but perhaps I can make
3687 it fairly clear to you.

Each establishment visited was investigated, first as to its water consumption, second as to the amount of chemicals or other matters which were used in the process of manufacture of the goods of that particular establishment. Next, the capacity of such vats or tanks or other receptacles in which dy-ing operations, bleaching operations, or similar operations were carried on, was determined, and also the manner in which the contents of those vats, tanks or other receptacles were discharged, whether it was discharged in bulk, or allowed to dribble out during the 24 hours of the day. In this way it was very possible to, arrive at quite actual figures as to the actual vo-ume of the trade wastes of an offensive character which would require to be taken into the sewer and which could not be discharged into the Passaic River without creating color or some other æsthetic nuisance.

Q. Who was to make that determination as to what part of the trade wastes was offensive and what was inoffensive so that it might be admitted into the trunk sewer?

A. I made those decisions in 1907 but eliminated from consideration only such wastes as were so highly diluted as to be only slightly colored, or as contained in them a small amount of other chemicals, acids, alkalis or otherwise.

Q. On your determination would some factories be permitted to pour their wastes, on your judgment of their character into the trunk sewer and other factories be excluded from the trunk sewers?

A. Yes sir, I think that is true.

Q. Do you understand that to be the present mode of selecting this ten per cent of trade wastes for admission to the sewage flow that should be carried and accom-odated in the trunk sewer project?

A. No, I cannot say that, I believe that point will be left until the

project is completed, I do not know that it has not been
3688 taken up already, but I certainly would be of the opinion and would so advise that the trunk sewer be used until the full project is completed to practically the limit of its capacity, if that capacity can be made up through the addition of inoffensive trade wastes or other diluting waters.

A recess was then taken.

Q. From all the data and observations and study that you have made of the Passaic Trunk Sewer project, do you now state that that is left to be determined as to which or what kind of trade wastes will be admitted to the trunk sewer, as you have stated?

A. That is so, yes, sir.

Q. Has there been any provision of law brought to your attention which would determine that fact other than the way in which you have testified to?

A. No, sir.

Q. I hand you what purports to be the report of the Passaic Valley Sewerage Commissioners to the municipalities lying in whole or in part within the Passaic Valley Sewerage District, dated 1908, and ask you if you have ever read or studied that report?

A. I have, yes, sir.

Q. I ask you if you have read chapter 10 of the laws of 1907 which is in the latter part of that report.

A. I believe I must have read it or glanced over it.

Q. Now I direct your attention to the latter paragraph of section 3 of that law, as appearing on page 2 marked with two Roman figures meaning "2", and ask if you have read this part of the
3689 law:—

In preparing the maps, plans and specifications for the intercepting sewer or sewers, plant or works to be made by the said Commissioners, as herein provided, and in making the estimate of the sewage capacity required for each municipality, regard shall be had by the said Commissioners both to the area and population to be provided for, making provision however, for not more than ten per-centum of the factory wastes and excluding all waste from gas works and all substances or discharges which may injuriously affect the intrgrity of the sewer or sewers then constructed." I now ask you if you have read that section of the law—the laws of the State of New Jersey, being Chapter 10 of the laws of 1907?

A. I have listened to your reading of that section of the law.

Q. Is this the first time your attention has been directed to that section of the law which measures what percentage of trade wastes are to be admitted to the trunk sewer?

A. Specifically, that is so.

Q. Now that your attention has been directed to that section of the law, what percentage or percentum of the trade or factory wastes are to be admitted to this trunk sewer and discharge at Robbins Reef?

Mr. Riker: The question is objected to on the ground that this

witness has not qualified as an expert *on* law, and that the intent of the act, if it is properly proved in the case, must be determined by the Court.

The Commissioner: Note the objection of counsel for the defendants.

A. That is, of course, a legal point which I am unable to interpret, but I see no reason to believe that in intent, any more was meant than that ten per cent of the total volume of sewage to be composed of trade wastes.

3690 A number of years ago, in 1910, to be exact, I referred to this point in an address made before the New Jersey Sanitary Association at their annual meeting, and in this address, I referred to it as follows:

"The restrictions surrounding the construction of this immense sewer require that each community shall be permitted to discharge trade wastes into it, with its domestic sewage, only to the extent of ten per cent of the total volume of the sewage of the community."

As that statement was made in December 1910, and the report of the Passaic Valley Sewerage Commissioners was made in 1908, I believe that my understanding of the proposition, eliminating the amount of trade wastes is now as it was then as above stated.

Q. Do you regard that inperpretation which you made in 1910 of the section of the laws of New Jersey, chapter 10 of the laws of 1907, to which I called your attention, as a misinperpretation?

A. It would be hardly proper for me to say that, but I might go as far as to say that I believe it was.

Q. Do you now find in the law I have directed your attention to ample provision for the apportioning the percentage of trade wastes to be carried in the trunk sewer?

Mr. Riker: The question is objected to on the ground that it is immaterial, irrelevant and impertinent to the inquiry, for the reason that the reduction in the amount of trade wastes to be carried and discharged by the sewer will have the result of decreasing the actual amount of pollution of the Bay of New York, if any, due to the discharge from the Passaic Valley Sewer.

The Commissioner: Note the objection of counsel for the defendants.

3691 A. If the restriction holds good to exclude from the sewer ninety per cent of the total volume of trade wastes contributed by the Passaic Valley district, it will be a matter of some difficulty to determine legally what actually constitutes a trade waste. In the case of Paterson the amount of trade waste- which are being discharged into the river at the present time, are, in round numbers 10 or 12 per cent of the total volume of the sewage discharged by that community meaning by that, offensive trade wastes. But Mr. Whipple reports a total volume of trade wastes from the city of Paterson in the neighborhood of 12,000,000 gallons per day; some where between 9 and 10 million gallons of these wastes are considered to be offensive. To exclude all but the ten per cent of the total volume of trade wastes of any character from the trunk

sewer, will be to put an unusual and unnecessary restrictive measures in force, which, in so far as I know, *have* never been operative in the case of any other sewerage project.

Q. Would it be necessary under the law to which I have called your attention, to depend entirely upon the factories to make the apportionment between the ten per cent which under the law would be received, and the ninety per cent which would have to be taken care of otherwise?

Mr. Riker: The question is objected to on the ground that it is immaterial, irrelevant and impertinent to this inquiry.

The Commissioner: Note the *on*jection of counsel, for the defendants.

A. No, sir, I do not think that it would. There will always be required a certain number of inspectors whose duty it will be to look into such matters as these, and it is perfectly feasible through the medium of such men to so proportion the amount of trade wastes which are discharged into the sewer from any establishment.

3692 Q. Would that entail an*d* inspector for every mill and factory and manufacturing plant using the trunk sewer to discharge the ten per cent of its trade wastes?

Mr. Riker: I make the same objection to this question as last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. No, sir. It is feasible to discharge these trade wastes through pipes or troughs in which might be placed self recording devices that would keep a continuous record on the volume of flow through these pipes or troughs and so check up the actual amount of trade wastes which enter the sewer from any given establishment.

Q. Will that entail the necessity of metering the sewers connnecting with the trunk sewers these various mills, factories and manufacturing establishments?

Mr. Riker: I object to the question on the grounds last stated.

The Commissioner: Note the objection of counsel for the defendant-.

A. I should not think it would necessarily entail metering it might entail continuous or intermittent measurements.

Q. Do you know where any such devices are now in use?

Mr. Riker: Objected to as last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. For the measuring of trade wastes do you mean, Doctor?

Q. Yes.

A. No, sir. It is never-the-less possible to make such devices *have* the Passaic Valley Sewerage Commissioners made provisions for such devices?

—. ——.

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

3693 A. Not to my knowledge.

Q. What provision has been made for excluding ninety per cent of the trade wastes, as to its disposal?

Mr. Riker: The question is objected to on the ground that there is no justification in the facts that have been shown for the assumption that ninety per cent of the trade wastes is to be excluded. The section of the Statute which has been referred to and upon which this witness is being examined as an expert, provides that in the construction of this work provisions shall be made for not more than a total of ten per centum of trade wastes in the district, and there is no provision in it, nor any actual requirement for excluding any of it.

The Commissioner: Note the objection of counsel for the defendants.

A. I am unable to cast any further light on this point.

Q. How are these trade wastes now discharged, and into where?

A. At present the trade wastes of the Passaic Valley district are either discharged directly into the Passaic River and its tributaries or into the sewage systems and thence into the Passaic River, or its tributaries.

Q. Is there any way of discharging the ninety per cent of these trade wastes that would be refused by the trunk sewer scheme?

A. There would not appear to be.

Q. Do you know if there was any estimate made of the volume of these trade wastes in 1907 or 1908 of the entire volume for the Passaic Valley Drainage area?

A. Yes, sir.

Q. What was the entire volume of those trade wastes?

A. Such an estimate was made in 1907 by me. The total
3694 volume of the trade wastes which the district considered in 1907 was figured at 12,889,000 gallons.

Q. As the total trade wastes?

A. As the total trade wastes of the entire district per day. Since half a dozen communities have withdrawn since that time it is necessary to revise these figures, making the estimated total amount of trade wastes contributed daily between 10 and 11 million gallons daily.

Q. What computation was made then as to the volume of trade wastes for the year 1940?

A. From such records as I have in my possession, I find that the total volume of trade wastes estimated for the year 1940, I think, or at the time when the Passaic Valley Sewerage project shall have been completed is given as 62,482,100 gallons per 24 hours. In explanation I desire to call attention to the fact that it was these data and other data contained in the same table which were used as a basis for the design of the trunk sewer, with regard to its maximum carrying capacity. The house sewage is given at a flat

figure of 150 gallons per capita, the ground water leakage is given at the maximum figure of 3,429,300 or, figuring this in another way, the ground water leakage is given as 44,037,800 gallons per day. The total sewerage though at the time the completed project shall be in operation caring for the sewage of 1,649,440 people, is given as 357,365,200 gallons. I want to still further call attention to the fact that although the average sewage flow is 240 million gallons as against 357 million gallons shown in this table, the difference of some fifty per cent is accounted for by the reason that it is necessary to figure maximum sewage flows in order to get at the carrying capacity of the sewer. The trade wastes which in 1907 were estimated at some 12 million gallons per day are given in 1940 at 62 million gallons per day. It is readily seen that these figures are all out of proportion to the domestic sewage flow, which
3695 is in direct proportion; that is made so, in the case of trade wastes, because due consideration was given to the manner in which these wastes were discharged, whether in bulk or dribbled out during the 24 hours of the day. The fact that many dye works, bleacheries and other establishments contributing wastes of an objectionable character which would require to be taken into the trunk sewer discharged the contents of their vats and tanks and other receptacles in bulk at one time and within a limited space of time, makes it necessary for the sewer to be able at such times promptly to carry away this abnormally large load, even though it is only temporary. That is responsible for these large figures under the head of trade wastes, which do not represent the average flow of trade wastes throughout three hundred and sixty five days in the year.

Q. What was the maximum capacity for the trade wastes of Paterson computed in that table?

A. This is scattered through (interrupted)——

Q. Let me see if I can give it to you in a compact state. I show you again the report of the Passaic Valley Sewerage Commissioners to the municipalities lying in whole or in part in the Passaic Valley Sewage District, for the year 1908, and direct your attention to page 15 of that report on which appears table "5," and ask if you have seen that table before the time I now show it to you.

A. This appears to be the same table that I referred to, although I have not been able to check the figures as given in this table.

Q. How do the total trade wastes in the table check with the total trade wastes given by you in your testimony just now?

A. They check.

Q. And amount to how much?

A. 62,482,100 gallons.

Q. Do you know who compiled these tables or how they were compiled?

3696 A. I have reason to believe that they were compiled in the office of Hering and Fuller, 170 Broadway, New York City.

Q. Did you participate in collecting the data and in the compilation?

A. I did.

Q. Directing your attention to page 14 of that report, I ask you if you regard the part I am just about to read as fairly representing the facts in regard to the compilation and collection of the data.

I read from the last paragraph on that page of the report now before you:

"The trade wastes were carefully ascertained and the flow is reported in table 5. In this table the rates of maximum flow as estimated, are shown, and the amount of each municipality are tabulated in million gallons per 24 hours. The total amount of over sixty two million gallons shown in the table represents the total daily flow of all trade wastes based on the maximum rate of flow."

Do you recognize that as a fair statement of the care with which these tables were compiled and the matter collected?

A. Yes, sir.

Q. Approximately how much of that trade waste would be contributed by the city of Paterson?

A. From the date given in table number 5, on page 15, to which you have just called my attention, roughly speaking the city of Paterson is shown to contribute trade wastes to the extent of about twelve million gallons, which is about 20 per cent of the total volume shown in this table. Again it becomes necessary for me to call attention to the fact that this does not represent the actual average for trade wastes for 24 hours, but it is the rate of flow on a 24 hour basis. It is the fact that during some time in the 24 hours of the day the maximum flow of trade wastes from the City of
3697 Paterson is equivalent to twelve million gallons per 24 hours. The actual amount discharged during 24 hours of the same day would be much less; probably much less than one third.

Q. On what do you base that one third computation, Mr. Johnson?

A. From observations which I have had occasion to make in years past, in which I have paid particular attention to this phase of the problem, I know it to be a fact that by far the largest bulk of the trade waste is first stored in vats and when the solutions loose their power for bleaching or for dy-ing the large outlets for these vats are opened and the whole volume of waste discharged at one time into the sewer.

Q. Did you make any direct observation of the trade wastes of the City of Paterson at any time?

A. I have been interested in the silk mills of Paterson for ten years and have been through many of them, and I have had occasion to look into the question of dy-ing processes; not only there but other places, as in Allentown, Pennsylvania, at the works of the National Silk Dying Company; so I have a fairly accurate idea of the amount of wastes which are objectionable and are not objectionable, discharged from dye works of this character. .

Q. Earlier in your testimony I understood you to say that you accepted the Whipple and Hazen report in relation to the trade wastes and sewage of Paterson, and that starting on the assumption of their adequacy, you directed your observations to the trade wastes

and sewage of the other towns along the Passaic River. Am I right?

A. As to the details of the trade wastes problem in Paterson, that is true; we looked into the matter in a general way but made no effort to obtain detailed figures in that city.

Q. Are you familiar with the silk industry in particular, as it is practiced in Paterson, as well as in the portion of Pennsylvania that you mention?

3698

A. I have been through all the departments, I believe, but I do not pretend to be an expert silk dyer.

Q. Approximately, how many pounds of silk are manufactured in Paterson every year?

A. I could not tell you.

Q. Do you recall that Messrs. Whipple and Hazen gave it as seven and one half million pounds?

A. I know that they gave the figures as they found them.

Q. Do you know whether or not two thirds of the whole manufactured silk in the United States, is manufactured in Paterson?

A. No, sir.

Q. Do you know how many gallons of water it takes to manufacture a pound of silk?

A. No, sir; those figures are all given in Mr. Whipple's report.

Q. He gives it as one thousand gallons of water being used for every pound of silk or for working days, more than twenty millions gallons a day or two hundred gallons per capita for the entire population. Do you accept those figures?

A. I do, and with the full knowledge that the vast bulk of those dye liquors is in such high state of dilution that they can safely and without offense, be discharged into the Passaic River without nuisance.

Q. Are any of the trade wastes of silk mills offensive that you know of?

A. They are very aesthetically offensive, because, if in their concentrated state, these spent dyes produce color.

Q. And only on color objection you would regard them as offensive?

A. There are certain chemicals used which, if in large amounts would prove offensive, because of their tendency to destroy fish life.

3699

Q. How much in excess of the public water supply is the water used in the manufacture of silk, per capita?

A. I should say in round numbers that it was double.

Q. So that in the case of Paterson and its silk mills the metered water supply would not give you an adequate measure of the sewage per capita of the population, would it?

A. In that case, no. And furthermore, in the case of dye works, particularly silk dy-ing works, we know that the dyers usually have a firm prejudice against the use of a water which has previously been treated with a coagulant, especially if that coagulant happens to be sulphate of alumina therefore we were in full possession of the

facts, namely, that the silk dyers for the most part relied upon other waters than the public supply.

Q. From what sources did they get these other waters, if you know?

A. As to that I am unable to say.

Q. How much soap is used in the silk works of Paterson for every pound of raw silk?

A. I am unable to give you the details on these questions you are asking If you desire them I can obtain shortly a copy of Mr. Whipple's report in which these statistics are fully set forth.

Q. Would you say that it was more than a pound to each pound of raw silk?

A. I have no knowledge whatever of the amount of soap used in Paterson in the silk dy-ing industry.

Q. Do you know whether or not that soap in large measure passes away with the trade wastes?

A. I would naturally assume that a great deal of it would be likely to provided it was not skimmed off and recovered.

Q. Do you know if they do any thing of that kind or subject the soap in the trade wastes, to any recovering process?

3700 A. I do not.

Q. What extractive matters of silk are carried off in the trade wastes?

A. I regret very much to state that I am not an encyclopedia on the silk industry; I wish I were.

Q. I place at your disposal the report of the joint committee on sewage disposal of the City of Paterson which has been alluded to in your testimony, and which you stated you accepted as representing material matters regarding trade wastes which you made a subject of your investigation, the consulting engineer being Allen Hazen, and the date of the report 1906. If you care to take issue on any statement I made which I draw from that, I will give you the page. Mr. Hazen states that for every pound of raw silk a pound or or more of soap is used. Do you accept that statement—you will find it on page 70?

A. I presume that he is repeating Mr. Whipple's statement and I would be merely repeating Mr. Whipple's statement through Mr. Hazen.

Q. In regard to the extractive matter of gum removed from the silk in the process of manufacture, do you regard it as putrescible?

A. I have made no study of the putrescibility of the so called silk gum.

Q. Mr. Whipple states on page 70:—

"This matter is putrescible and contributed in a substantial degree to the pollution of the river." Do you accept that statement after Mr. Whipple had investigated the matter?

Mr. Riker: The question is objected to in that it contains a statement by counsel that certain things are facts, which may or may not be facts as counsel may be properly informed or not properly

informed, but certainly has not been proved in this case, and are not therefore the subject of inquiry.

3701 The Commissioner: Note the objection of counsel for the defendants.

A. On page 12 of Appendix 1 of Mr. Hazen's report I find a statement, by Mr. Whipple bearing on this point, in which he says:—

"For most purposes most of the gum is boiled off, but for souple silks that is, soft and pliable silks, only a part of the gum is removed; and for surah silks very little gum is removed, but the soupling baths are soapy and should be discharged in the sewers; subsequent wash waters may be allowed to go into the river."

Q. Directing your attention to page 70 of the report, do you find there a statement that Extractive matter or gum is putrescible, and contributes in a substantial degree to the pollution of the river?

A. I find such a statement on page 69.

Q. Are many chemicals and dyes used in the process of dy-ing silks?

A. Quite a number.

Q. Will you name some of them, please?

A. That depends, of course, on the character of the silk which is produced.

Q. In general in the silk industry, name some number of them?

A. I know in a large number of Japanese silks, zinc plays a pretty important part because it has weight, and silk is sold in many cases by the pound.

Q. They weigh all silk do they not, before dying them?

A. I believe so.

Q. Do you know whether or not the water in these dye houses is ground water?

A. As a general proposition, if ground water is available which does not contain large amounts of iron, such waters are

3702 generally considered to be very good for dy-ing purposes, provided they are not too hard and require abnormal quantities of soap for softening.

Q. Do you know whether or not a considerable portion of the water used in the dye houses in Paterson, is ground water?

A. I don't know that of my own knowledge.

Q. What do you say as to the character of the trade wastes from the dye houses, these dye house liquors are they offensive or inoffensive?

A. I believe, in answering that question, I can do no better than to quote from page 69 of Mr. Hazen's Paterson report above referred to, as follows:

"Of the injurious and polluting substances, by far the greatest quantity is carried by comparatively small volume of concentrated liquor, not exceeding five or at most ten per cent of the total volume of water used in the dye houses. Certain further quantities of discharge contain some polluting materials, but the great bulk of discharge consists of wash water containing only mineral substances

or organic substances in such small quantities that they do not pollute the river."

Of that, how much did he recommend should be removed, of the total volume of the trade wastes?

A. About five per cent of the total volume.

Q. Equal, to what?

A. Or one million gallons per day.

Q. Does he qualify that in any way?

A. He states on page 70,—

"Owing to the difficulty or impossibility of effecting accurately such a separation, the amount actually to be taken care of will perhaps be double this quantity."

Q. Will you turn on page 3 of Mr. Whipple's special report on the composition of Paterson sewage; I will ask you, if it is necessary before designing works for purification, to
3703 know the character of the sewage to be dealt with, if that is an essential for the sanitary engineer?

A. It is, yes, sir.

Q. Do you also have to take into consideration the condition of the sewage with respect to its decomposition?

A. Ordinarily no.

Q. Did Mr. Whipple in his report regard that as an important factor,—the third factor which he considers?

A. He has advanced a truism here on page one, appendix 1, where he states:

"The sewage of a city where the combined system of sewage is used, consists of:

(1.) The public water supply soiled by the waste products of human beings.

(2.) A certain amount of ground water which leaks into the sewers and which is usually more or less polluted.

(3.) Amounts of wash waters from the streets, roofs of houses, and so forth, which varies both in quantity and quality according to the rain fall, and

(4.) The waste waters from manufacturing establishments, soiled in various ways, according to the nature of the industry."

Q. I direct your attention to page three, and in the light of my question will you answer whether or not the third factor considered by Mr. Whipple was as to the condition of the sewage with respect to its decomposition?

A. Yes sir. I find on page three, appendix 1, the statement:

"The condition of the sewage with respect to its decomposition but this can usually be forecasted if the age of the sewage at the time when it reached the purification works is known."

Q. He states that as his third factor?

A. Yes sir.

3704 Q. What are the most important constitutents of the sewage necessary to be know- in planning for purification works?

A. There is no general blanket rule which covers the type of purification works which may be adopted and the capacity of them

works properly and efficiently to do the work required of them. In some cases a complete degree of purification is required that is usually almost exclusively, restricted to inland places where the sewage effluent is discharged into running water ways which water ways are used later on as sources of public water supply by the cities lying further down the stream. Complete purification, or as complete as is commensurate with *fdficiency* and cost, is usually adopted in such cases. Other cases where the opportunity for dilution are at a maximum as in the case of large lakes and ponds, may satisfactorily solve the sewage problem by removing from the sewage the suspended solid matters and as a final point of the refinement required, provided the dilution is sufficient to preclude the setting up and maintenance of offensive conditions, is in some cases sterilization of the clarified sewage. In considering an individual problem these questions are always given much thought. On a stream where the nearest water works is one hundred or more miles further away and where the opportunity afforded for adequate dilution are perfect, it is not proper, or at least it is not considered improper by a large number of sanitarians to adopt a process of purification whereby the sewage shall be thoroughly screened and afterwards settled to remove the suspended solids, and in some cases sterilizing the affluent either before or after passing it through some form of subsidiary treatment, such as sprinkling filters, or contact filters which are composed usually of broken stones or slag, and which in effect are not precisely filters but more in the nature of biological machines. We know perfectly well from our own experience, and experiences in England and Germany in particular, about how many people can be
3705 cared for per acre of surface of sprinkling or contact filters and we might say, roughly speaking, that in treating the average American sewage the sprinkling filter will probably take care of the sewage discharge of twenty thousand people per acre of filtering surface. These are only general figures but we rely particularly in arriving at the solution of such questions as involve final and complete purification, on the number of people contributing sewage rather than the precise composition of the sewage itself.

Q. Is there any provision in the sewage disposal scheme of the Passaic Valley Sewerage Commission for these stones or biological filters which you have just described.

A. There is not.

Q. How much of the organic matter will be removed by the screens such as described in the stipulation between the Federal Government and the State of New Jersey and marked in this case as complainants' exhibit No. 135?

A. As the result of my observations, and basing my statement upon the results which have actually been affected by screening sewage in various parts of the world, it is possible for me to make the statement that the amount of suspended matter removed by screens will vary from fifteen to fifty per cent of the total suspended matter contained in the sewage.

Q. How fine a mesh would a screen need to have to remove fifty per cent of the suspended organic matter in the sewage?

A. The screens that I have referred to as removing fifty per cent of the suspended matter are of the type used in Dresden where the sewage after passing through the grit chamber is passed through a disc screen which is about five feet in diameter and has openings about one one twelfth of an inch in the clear these openings are rectangular slots.

Q. How fine are the meshes of the screen to be employed by the Passaic Valley Sewerage Commissioners as set forth in the plans for the disposal of the Passaic Valley sewage?

3706 A. It is set forth in the stipulation that the self cle-nsing mechanical screens shall have clear openings of not over four tenths of an inch.

Q. Is that a fine or a course screen?

A. Four tenths of an inch is a fine screen.

Q. How would you describe the Dresden screens of one twelfth of an inch?

A. That is a very fine screen.

Q. What would you call a course screen?

A. A screen which would be termed a course, and which is usually termed a course screen, is where the bars of the screen are set some two to four inches apart. The purpose of that course screen is to remove heavy floating particles which might get into the pump and cause damage.

Q. And it is not for the purification process proper?

A. They take out some material, but their purpose is as stated.

Q. How much of the organic suspended matter will be removed by a screen with a four-tenths of an inch mesh?

A. The best data on that point are found in "Principles of Sewage Treatment" by Professor Doctor Bunbar, edition of 1908 page 257.

Q. I desire to get your experience, not Dr. Dunbar's.

Mr. Riker: Won't you read that question, please.

(The stenographer read the last question.)

Dr. O'Sullivan: That is from your own experience.

A. I have figured that about twenty per cent, as a maximum, should be anticipated as the efficiency of these fine screens, or screens having openings of four-tenths of an inch.

Q. Twenty per cent of what?

A. Of the total suspended solids.

Q. How about the organic matter as a whole?

A. The amount of organic matter which will be removed by screens of this kind will vary with the composition of the

3707 sewage, of course, you want my own observations, I believe?

Q. Yes.

A. It is a fact nevertheless, that data on this point are very scant, it being a point which has not had particular attention paid to it in the past.

Q. In the operation of your experiments at Columbus how large a mesh did you use in the screens for the treatment of the sewage?

A. The sewage was passed through three screens having clear openings of one-half inch, one-half inch and 3.75 inch, respectively.

Q. Will you express the last in an approximate fraction?
A. It is a little better than one-third of an inch.
Q. And that is a finer than the screen proposed to be used by the Passaic Valley Sewerage Commissioners, is it not?
A. About the same.
Q. One-third of an inch?
A. Oh, a finer screen you say?
Q. It is a finer screen is it not?
A. There are two one-half inch screens and one a little over one-third of an inch.
Q. I say the one-third of an inch screen is a finer screen than that proposed to be used by the Passaic Valley Sewerage Commissioners?
A. It is so slightly less that it is hard to measure; it is 4.00 in the case of the Passaic Valley stipulation as against 3.75.
Q. How would you express four-tenths of an inch in a finer fraction?
A. Two-fifths of an inch.
Q. Which do you regard as the finer screen, that fine screen at Columbus, or this screen that the Passaic Valley Sewerage Commissioners propose to use?

3708 Mr. Riker: The question objected to on the ground that it does not appear what the Passaic Valley Commissioners propose to use except that they will not use one having a larger mesh than a certain designated size.
The Commissioner: Note the objection of counsel for the defendants.

Q. With that limitation will you answer my question, Mr. Johnson?
A. The final screen was somewhat finer than the stipulation calls for as a maximum size in the case of the Passaic Valley project.
Q. You had three sets of screens in Columbus; how many sets of screens are provided for in the sewage disposal scheme proposed by the Passaic Valley Sewerage Commissioners?
A. There are two sets of screens mentioned in the stipulation. At Columbus the extra screen was made use of because of the fact that the sewage used for the tests was taken from an intercepting sewer running some twenty odd feet below the ground. We boxed in the pump suction in this sewer and screened one side of it in order that the sewage entering the pump suction should not contain particles of rags and similar materials which would clog the pump and cause trouble in that way; that was the occasion for the extra screen.
Q. Are pumps to be used by the Passaic Valley Sewerage Commissioners at the sewage disposal works?
A. I believe they are, yes, sir.
Q. Would that provision at Columbus which you put in operation there be a good provision to protect these pumps also?

Mr. Riker: Counsel for the defendants objects to the question on the ground that it is immaterial to this issue.
The Commissioner: Note the objection of counsel for the defendants.

3709 A. For what I have seen of the plans and on reading the stipulation I am inclined to the belief tha- ample provision has been made to protect the pumps against injury.

Q. Does that rate of flow in any way influence the efficiency of the screen?

A. Within certain limits it is a fact that high velocities tend to force matters through the open spaces in the screen and so reduce its retaining capacity for suspended solid matters.

Q. What was the rate of flow to the screens in the Columbus plant which you operated, approximately?

A. I shall have to figure it for you, sir, we did not pay any attention to that; I can figure it very shortly.

The theoretical lineal volicity or flow to the screen chamber at Columbus was about nine feet per minute.

Q. What is the calculated lineal velocity of flow for the sewage toward the screens, at the Passaic Valley Sewerage disposal works?

A. I do not find that in the stipulation, therefore I am unable to answer it.

Q. Are you prepared to say whether it would be greater or less that the rate of velocity toward the screens of the Columbus plant?

A. No sir, I am unable to answer the question.

Q. What was the detention period in the grit chamber in the Columbus plant?

A. During the period February 18, to June 30, 1905, the retention period in the grit chamber was .29 of an hour.

Q. What page of your report is that on?

A. Page 79.

Q. Turn to page 2151 and see if it is stated differently?

A. No sir, it is here stated as three-tenths of an hour instead of .29 of an hour; one-one-hundredth of an hour different, some-

3710 thing less than a minute.

Q. These is a difference, however?

A. I think probably they were just the same.

Q. What is the period of detention calculated for the grit chamber of the Passaic Valley Sewerage Commissioners?

A. I do not find that in the stipulation therefore I am unable to answer.

Q. Do you know whether it is the greater or less period of detention.

A. I do not, no.

Q. How long did it remain in the grit chamber, on an average in the Columbus plant; the detention period, I am trying to get at.

A. That was a variable factor depending almost entirely on the composition of the sewage which varied from time to time, and on climatic conditions.

Q. Did you make a sum-ary of the observations, taking into consideration such variations as would come with climatic or other conditions?

A. I did, yes sir.

Q. I direct your attention to page 151 of that report (Last question here read to witness).

See if you have stated them there.

A. I misunderstood your question, I thought you asked how long did the suspended matter remain in those tanks.

Q. I am speaking of the raw screened sewage which you have described as being sent to the grit chamber.

A. The period of detention in the grit chamber during the Columbus experiments between the dates August 16, 1904, and February 17th, 1905, was one and a half hours; from February 18th, to June 30th, 1905, the detention period was half an hour.

Q. Taking the detention period of one and a half hours, how does that compare with the detention period provided for in the plans of the Passaic Valley Sewerage Commissioners as to length of time?

3711

A. I do not find that specified in the stipulation and am unable to answer the question.

Q. With a detention period of one and a half hours for raw screened sewage going through these three sets of screens, how much or what percentage of the removal of the suspended matters were you enabled to get. Is it not given on page 151?

A. Yes, sir, but there is one thing that is not stated in the table on page 151, and that is the velocity of flow which has every thing to do with the efficiency of a device of this sort, in the removal of suspended solid matters.

Q. What was the velocity flow with the detention period of one and a half hours by which you found thirty-four per cent removable of the suspended matter?

A. The velocity was 2.61 millemeters per second.

Q. What would that be in feet, roughly or approximately?

A. I suppose it would be close enough to call that about one-tenth of an inch per second.

Q. You considered that work satisfactorily, did you not, and successful?

A. We did not. We found before the experiment ended, as evidenced by the fact that we changed the velocity and period of retention in the grit chamber on February 18th, some four and a half months before the experiments closed, that so much suspended matter was deposited in the grit chamber of an organic nature that septic actions were set up in the deposits causing them to be blown to the surface. During the evolution and ebullition of gas, and that interfered with the process, and subsequent processes, to such an extent that we cut it down in order to get more nearly a true grit chamber such as is used in practically all purification works.

Q. As the result of that experiment did you conclude that the detention period of one and a half hours was too long?

3712

A. For the purpose for which the grit chamber was intended, Yes. We did not want to get septic action in that chamber and we did get it.

Q. And that was the highest per centage that you were able to settle with that detention period, was it not, thirty-four per cent?

A. Yes sir.

Q. What is the detention period provided for in the Passaic Valley Sewerage Commissioners' plant?

A. I do not find that with regard to the grit chamber.

Q. How with regard to the sedimentation plant?

A. I find it is stated in the stipulation that the mean velocity through such tanks shall not be over five-tenths of an inch per second for average flow, and seventy-five one hundredths inch for the maximum flow.

Q. What detention period would that give for the screened sewage in the sedimentation tank or tanks?

A. Under average flow conditions such tank is stipulated to have a detention period of one and a half hours and under maximum conditions of flow a detention period of not less than one hour.

Q. What percentage of the organic matter would you expect to be sedimented under the conditions you have now described as to these detention periods?

A. I have considered that under such conditions there should be deposited at least thirty per cent, or in round figures one third of the suspended matters in the sewage applied to the tank?

Q. Then what would occur to the other two-thirds, it would pass on with the effluent, would it not?

A. No sir, I feel that in the screening device there will be removed suspended matters amounting to, in round numbers, fifteen per cent of the total suspended matters in the crude sewage. I am able to arrive at this conclusion for the reason that care-
3713 ful observations have been made on the operations of a screen of this character located in Hamburg, Germany, such observations having been made by Professor Doctor Dunbar, and referred to in his book "Principles of sewage treatment," page 275, as follows:—

"The amount of the solids removable from sewage by means of gratings, screens, etc., varies very considerably, as is only to be expected from the variations in the forms of apparatus described in chapter seven. If we leave out of consideration screens which are intended primarily to protect the sewage pumps and which have therefore very wide openings, and if we only consider those forms of construction which are intended to reduce the amount of suspended solids, if may be stated that a pound of material is removed for every 22 to 45 persons according to the size of the appertures of the screens, namely, 1.3 to 2.6 cubic yards per day for the sewage of a town having a population of one thousand."

Ratios of a pound of a material removed for every 22 to 45 people are equivalent to 20 to 40 grams per capita per day. With screens of the Hamburg type the lower ratio of 20 grams per capita per day may be taken as to efficiency of the screen, on the basis which I have figured with regard to the probable composition of the Passaic Valley Sewage, namely 75 grams per capita, representing the total suspended matter in that sewage, the removal of this suspended matter by screens of the type used in Hamburg, where the opening between bars is approximately four tenths of an inch would be 26.70 per cent. This is in excess of the figure I have just stated

and is based on actual results with a screen of a type in general accord with the screen described in the stipulation.

Q. In the calculation which is made of grams per capita do you take into consideration the percentage of organic trade wastes to be dealt with?

3714 A. I do, yes sir.

Q. What was the highest per centage of removal that Dr. Dunbar was able to get from the municipal plant at Hamburg?

A. I have not noted that he recorded the variation in per centage, removable in this case.

Q. What was the highest per centage of removal of organic matter that you achieved in the Columbus, Ohio, plant, without chemical precipitation, and with a detention period of one and a half hours?

A. You refer to tank treatment?

Q. Screening and tanks.

A. Screening and tank treatment?

Q. Yes. You will find it on page 151 I think.

A. No, that only gives the result of sedimentation, there is nothing there on screening.

Q. I call your attention to the second paragraph, under the caption of "summary," on page 151 of the Columbus report in which you state that the table following applies to raw screened sewage?

A. That is true, but no allowance is made for the suspended matters removed by screens.

Q. What was the aggregate?

A. That is what I am trying to ascertain, it was not figured.

Q. What percentage of removal of organic matter would you expect, or could be achieved by the scheme proposed by the Passaic Valley Sewerage Commissioners in the sewage disposal plant to be installed at somewhere near the Newark meadows?

A. I have already come to the conclusion that the removal of total suspended matters by the devices called for in the stipulation would be about fifty per cent of the total. So far as answering your specific question of how much of the total organic matter contained in the sewage in a suspended state would be removed by this

3715 device, I shall have to ask you to let me figure for a moment.

I can, however, state in general terms that in my opinion there will be a removal of total nitrogen eq-ivalent to 40 per cent, of fatty matters of 50 per cent and of total suspended matters of 50 per cent.

Q. How much would that leave of the organic matter in the effluent?

A. That would leave 60 per cent of the nitrogenious matters and 50 per cent of the total suspended matters.

Q. In the effluent?

A. In the effluent.

Q. And the effluent you would describe, would you not, as what was left after this treatment?

A. Yes sir.

Q. Could these works be operated on the Newark meadows without giving rise to nuisances or offense of any kind?

Mr. Riker: The question is objected to as an immaterial inquiry in this case and in no way concerning the complainant.

The Commissioner: Note the objection of counsel for the defendants.

A. I believe that they could, basing my judgment on personal observation of sewage works in this country and abroad, in England especially where such works as these are immediately along side of public high ways and close enough to toss a stone into and in some cases in residential sections of some class.

At this point the further taking of testimony on behalf of the defendants was adjourned to Wednesday the 19th day of February, 1913, at 10:30 o'clock A. M. at the office of Messrs. Riker and Riker, Newark, New Jersey.

3716 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker and Riker, Newark, N. J., Wednesday, February 19th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esq., Attorney General of the State of New York; William A. McQuaid, Esq., Deputy Attorney General; Dr. William J. O'Sullivan, Special Counsel, for the People of the State of New York, Complainants; Edmund Wilson, Esq., Attorney General of the State of New Jersey; Robert H. McCarter, Esq., of Counsel for the State of New Jersey; Adrian Riker, Esq., of
3717 Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

GEORGE A. JOHNSON assumes the stand.

Further cross-examination by Dr. O'Sullivan:

Q. What is the area of the drainage basin of the Passaic River?

A. I have already testified to the fact that I am unable to state this area but referring to what I believe to be a copy of the 1908 report of the Passaic Valley Sewerage Commissioners, I find the staatement that; "The present sewerage district was created by an act of the Legislature of 1902 and covers an area of about 77 square miles, upon which in 1905 lived a population of 572,200 persons.

The area outside of the present district for which it seems desirable to make provision in the proposed sewer capacity was fixed as follows after careful, consideration. To the North and east of Paterson and between it and Garfield there is an area contributory directly to the Passaic Valley of 10.8 square miles."

Q. Will you refer me to the part of the report where that appears.

A. The only statement I find of a specific nature bearing on this point is contained in the published report of the Passaic Valley Sewerage Commissioners, of 1908, page 7 as follows: "The present sewerage district was created by an act of the Legislature of 1902 and covers a area of about 77 square miles upon which in 1905 lived a population of 572,200 persons. The area outside of the present district, for which it seems desirable to make provision in the proposed sewer capacity was fixed as follows after careful consideration. To the north and east of Paterson and between it and Garfield there is an area contributory directly to the
3718 Passaic Valley of 10.8 square miles. This area includes a portion of Prospect Park not included in the drainage area of Olderbrook, Gafflebrook and portions of Hawthorne, Ridgewood, Greenrock, and Saddle River Township."

Q. Where would this territory drain directly into, that you have just read?

A. "Naturally this territory would drain directly into the Passaic River through a series of short sewers."

Q. You have now read from page 7 of the report of the Passaic Valley Sewerage Commissioners to the municipalities lying in whole or in part within the Passaic Valley Sewerage District dated 1908, have you not?

A. I have, yes sir.

Q. My question, Mr. Johnson, calls for your estimate of the drainage basin of the Passaic River, the area of that drainage basin.

A. The drainage area of the Passaic River in so far as the Passaic Valley sewage project is concerned, I take to be from the above statistics about 87.8 square miles. I have no knowledge of the total drainage area of the Passaic River at hand.

Q. Have you read or studied the report of the joint committee on sewage disposal of the city of Paterson furnished to the City of Paterson in 1906, and which you described previously as the Hazen and Whipple report?

A. I read such a report shortly after its publication and have referred to it many times since then.

Q. On page 5 of that report it is stated:—

"Its drainage basin (meaning the Passaic River) covers 949.1 square miles."

Have you any reason to doubt the accuracy of that estimate?

Mr. Riker: The question is objected to on the ground that it is based upon the statement of fact with regard to this report which has not been proved.

3719 The Commissioner: Note the objection of counsel for the defendant-.

A. I assume that the statement you have made is correct, although I have no precise knowledge.

Q. I show you what purports to be a printed copy of the report itself, of the joint committee on sewage disposal of the city of Paterson, and call your attention to page 5 of that report, and under the heading of "Passaic River", ask you if it is not set forth that its drainage basin covers 949.1 square miles?

Mr. Riker: The question is objected on the ground that if the report, or any part of it is to be used in this way, it should be proved and admitted as an exhibit.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: The question is pressed for the reason that there is a provision in the law creating the Passaic Valley Sewerage Commissioners to take over all the reports, plans, specifications and investigations of the city of Paterson on the payment of a stipulated sum of money, and on the city of Paterson officially signing the contract to enter into the Passaic Valley Trunk Sewer project.

A. I find such a statement made in the report mentioned.

Q. In computing the total volume of the trade wastes for year 1907, what was your estimate of their entire volume for the Passaic Valley?

A. 12,889,000 gallons per day.

Q. That is the total volume you have now given me?

A. That is the total volume figured in 1907.

Q. What investigation was made relative to the quality of those trade wastes other than what you have already stated in your testimony?

A. Careful investigation of the trade wastes of the various
3720 communities was made and the result reported in considerable detail. Those details have not as yet been read into the record, but if you desire them I will do so. Do you desire them?

Q. Yes.

A. I will read the following from my typewritten notes bearing on the subject. These notes were prepared from data obtained by the various field men and were compared by me so that I am able to testify to their substantial correctness.

Q. In what did the comparison consist, Mr. Johnson?

A. The records were obtained by the field men and recorded in the field books; they were brought to my office and there I made a transcript of those notes and the typewritten copy I have before me represents my digest of these details.

Q. You said you compard them with something; I wish to know with what you compared them.

A. With the original field notes in order that no mistakes might creep into the typewritten copy.

Q. Then as I now understand it the digest which you are now

about to read you compared with the original field notes from which the digest is made?

A. That is so, yes sir.

Q. That is the only check or comparison that you made with any other standard?

A. As a whole that is true. But it is also true that I made several trips to the Passaic Valley District for the purpose of personally investigating the trade wastes problem in order to check up the results which were obtained by the field men. These trips on my part did not cover, however, the entire investigation.

Q. What did you do on these trips, Mr. Johnson, in the way of making any direct examinations yourself?

3721 A. During the investigations, and particularly in the beginning, I accompanied the field men and instructed them as to the data desired and how to obtain them.

Q. Were any chemical determinations made during the progress of the field work?

A. Not as regards the composition of the various trade wastes in themselves.

Q. Were any chemical determinations of any kind made during these operations by either yourself or the men who were doing the field work?

A. Only with respect to the amount of dissolved oxygen in the various sewers discharging into the Passaic River.

Q. Were any other determinations made of that sewage than the oxygen determinations?

A. No sir.

Q. What method was used in making the oxygen determinations?

A. The method described in the report of the committee on standard methods for water and sewage analyses, published in 1905?

Q. Do you know the method which is known to engineers as the Winkler method?

A. Yes sir.

Q. Was that method used?

A. There are parts of all methods for the determination of dissolved oxygen which are incorporated in the standard method above referred to.

Q. I ask you if the Winkler method was employed on that occasion when you examined the sewage in those trunk sewers?

A. It was.

Q. What other methods of oxygen determination do you know of beside the Winkler method?

A. There are methods which prior to the publication of the report on standard methods, among the more prominent being the method of Thresh and the method of Levy.

3722 Q. Have you ever heard of the Letts-Adney method?

A. I believe that to be a method which has been developed since I was a member of the committee on standard methods.

Q. How does the Winkler method differ from what you have described as a standard method?

A. In hardly any essential particular.

Q. Will you describe the standard method, Mr. Johnson?

A. In as much as I aided in the preparation of this report and in order to make the record clear, I believe I can do no better than to read the standard method used by us in the determination of dissolved oxygen in the discharge of the sewers entering into the Passaic River in 1907.

Q. Who prescribed it as a standard method?

A. The committee on water and sewage analyses.

Q. Did the American Health Association ever endorse that method?

A. Yes sir.

Q. And it appear- in any of their reports does it?

A. I- does.

Q. Will you describe the method employed? Before doing that will you please tell me what report you read from?

A. The report of the committee on standard methods of water analysis made up to the laboratory association of the American Public Health Association, and presented at the Havana meeting January 9, 1905.

"Determination of dissolved oxygen", Page 74 of above report.

Q There are three methods in use for the determination of atmospheric oxygen dissolved in water, namely those of Winkler, Thresh and Levy. Each of these methods has its own particular field of usefulness, all are capable of giving sufficiently accurate results.

"The Winkler method is in the most common use in this
3723 country and possess the advantages of requiring only simple and not readily breakable apparatus. It is therefore recommended as the standard method.

"The method of Thresh — perhaps slightly more accurate than the Winkler method, but the apparatus is not so well adapted for field work. For certain purposes, however, as for example the determination of dissolved oxygen before and after incubation, it is more practical than the Winkler method because the apparatus allows of the taking of representative samples direct from the bottles or other containers.

"What is true of the Thresh method is also true, to a great degree of the Levy Method. With both of these methods the samples are taken in a special stopper separatory funnel."

Reagents.

The reagents used in making the determination are manganous sulphate solution of sodium, hydrate of potassium, iodine solution sulphuric acid and sodium thiosulphate solution; starch solution is used as an indicator.

"In collecting the samples it is always necessary to guard against the entrainment of any oxygen from the atmosphere. The sample bottle is usually glass-stoppered, has a narrow neck and holds about two hundred and fifty centimeters. If the sample is to be collected from a tap the water is made to enter the bottle through a rubber tube which reaches to the bottom of the bottle, the water being

allowed to overflow for several minutes, after which the glass stopper is carefully replaced so that no air bubble is caught beneath it.

"When the samples are collected from the surface of a pond or tank two bottles are used, one being the ordinary sample bottle and another a bottle of about four times the size of the sample bottle. Both bottles are provided with temporary stoppers of double perforations, and in both cases a glass tube extends through one hole
3724 of the stopper to the bottom of the bottle and a short glass tube enters the other hole of the stopper but does not project into it. The short tube of the sample bottle is connected with the long tube of the same. In collecting the samples, the sample bottle is immersed in the water and suction applied to the short tube of the large bottle and enough water drawn through the hole to fill the large bottle. In this way the water in the smaller bottle will be changed several times and a fair sample obtained."

Q. Was that done in these determinations that you made of the sewage of these trunk sewers or out-falls?

A. Wherever it was possible this method was used. In some cases it was not feasible to enter the sewer, and in those cases a large bucket of the sewage was drawn up from the sewer and the sample bottle filled from it as above described.

Q. Was any other safeguard adopted prior to taking the oxygen reading itself either before using the reagents or during their use?

A. The only safeguards taken were to avoid the entrance of air into the bottle at any time, and the determination was made promptly after collection of the samples its temperature being recorded at that time, in as much as the temperature has considerable effect on the quantity of dissolved oxygen which the water can contain.

Q. Then the only determinations made were those for oxygen, is that right?

A. Yes, sir, that is so, with the exception of a few determinations made at the time the dispersion tests with the red dye were made in the harbor; at that time a few determinations were made of the amount of chlorine in the water at the point where the pontoon was anchored and at different depths.

Q. Was that made chemically or with the use of a salinometer.

3725 A. That was made chemically.

Q. What did you find the salinity to be at that point in the upper bay where you made your determinations?

A. My memory is fairly clear on that point and I remember distinctly that the chlorine contents of the water on the day of the analyses ranged from some nine thousand to some twelve thousand parts per million.

Q. Do you call that a high or low salinity?

A. In round numbers it is about half the salinity of sea water.

Q. So that you would describe it as brackish water.

A. I presume you would describe it as brackish water, yes, sir.

Q. About these determinations in the Passaic River itself; did

you make any determinations in 1907 that you have been describing other than the oxygen determinations of the sewage?

A. I do not recall that we did.

Q. Did you make any oxygen determinations at any point in the river itself?

A. We did not for the reason that it was clearly evident that the Passaic River contained no oxygen at that time.

Q. How was that evident to you?

A. From the fact that the surface of the river practically at all times on which I have had an opportunity to view it, and particularly in its lower reached, is covered over the most of its surface with bursting air bubbles which can only come from the results of putrefactive agencies actively going on in the deposits on the bed of the stream. These agencies speedily result in the complete absorption of whatever atmospheric oxygen the water may contain.

Q. Do you describe them properly as air bubbles, Mr. Johnson?

A. In the sense that air is a gas, yes sir.

3726 Q. Then there was air in those bubbles?

A. I presume that is a fine distinction; probably those bubbles contain marsh gas, and other gaseous results of bacterial *putrefaction* and decomposition.

Q. Was any effort made to determine as to what gaseous product of this decomposition consisted?

A. No sir, I have made determinations of that sort but not in the Passaic River.

Q. Was there any other effort made during your investigation to determine the quality of this sewage other than the oxygen determinations that you described, during 1907?

A. I believe we roughly recorded the odor of the samples as drawn from the sewer.

Q. Do you remember what that odor was described by you as?

A. Yes sir. Of the discharge of the thirteen outlets referred to previously in my testimony the odors were recorded in the case of each, respectively, as follows: "very faint" "cesspool" "faint" "Cesspool" "Musty" "Cesspool" "painty" "faint" "cesspool" "Cesspool" "cesspool" "cesspool" "cesspool".

Q. What did that term "cesspool" distinguish the sewage as in making that odor, what appearance?

A. The characteristic odor of decomposition of sewage.

Q. When you employ the term "faint" what did that import as to odor and the appearance?

Mr. Riker: If it did import any thing as to appearance.

A. The term "faint" refers to any very slight odor which was apparent.

Q. Was it by the appearance and the odors such as you have just detailed that you separate these sewages into offensive and inoffensive?

A. As a matter of fact we never separated the discharge of these sewers into classes; we merely determine the dissolved oxygen contents in each and record the odors as recorded above.

3727 Q. Upon what did the classification "offensive" and "inoffensive" depend?

A. We made no such classifications.

Q. Neither for sewers or trade wastes?

A. In the case of sewage, no; in the trade wastes "Offensive" was the term used to designate wastes of a character which would be likely to set up offensive conditions in the river if discharged into it in sufficient volumes.

Q. The classification then did not depend upon any odors or any appearance that the sewage conveyed to those who examined it?

Mr. Riker: I object to the question in that it is not definite, the subject having been trade wastes to which the word "offensive" has been applied and not to the word sewage.

The Commissioner: Note the objection of counsel for the defendants.

A. No sir, for the reason that these wastes as discharged were fresh and had not in a majority of cases undergone such changes as would make them offensive to the senses.

Q. Were any of these sewers discharging directly from factories?

A. I have been testifying as to trade wastes; I should like to make that clear. But in one of the samples collected, in as much as the odor is described as "painty" I judge that this was directly connected with the sewer. There are undoubted nemurous instances where this is true in the case of the sewers discharging into the Passaic River.

Q. My question was directed to elicit the fact, Mr. Johnson as to whether or not any of the sewers examined in 1907 either by yourself or the field force discharge directly from factories or manufacturing plants of any kind?

A. We made no note of this point in connection with our study of the discharge of those thirteen sewers.

3728 Q. In 1907 what was the estimate of the total volume per day in gallons of the trade wastes expected to be discharged in 1940?

A. In 1907 it is estimated that the total amount of trade wastes which would be required to be taken into the trunk sewer was 12,889,000 gallons per day; I am of the impression that no estimate was made of the probably quantity of trade wastes to be expected from the entire district in 1940. The trade wastes, in all probability, would not increase in volume in proportion to the sanitary sewage flow.

Q. Were there any estimates at all made of the entire volume per day in gallons of what was anticipated to be the total volume of the trade wastes for 1940, during these estimates that were made in 1907?

A. Yes, such estimates were made in order that the maximum carrying capacity of the sewer might be determined. The probable amount of trade wastes, in average daily volume, in 1940, was not estimated. In estimating the maximum flow of trade wastes at any particular minute in the 1440 minutes of any particular day it was

figured that trade wastes would be flowing in the sewer at the rate of 62,482,100 gallons per 24 hours. This is meant to represent the maximum rate of flow in the sewer at any time and not the actual daily volume of trade wastes to be expected in 1940.

Q. How would it compare with the daily volume of the trade wastes to be taken into the intercepting sewer?

A. The maximum rate of discharge of trade wastes through short periods of time would probably be in the neighborhood of three times the average daily flow.

Q. What was the estimate for the entire volume of trade wastes of the region to be served by the trunk sewer project, apart from the ten per cent that was to be carried in the trunk sewer?

3729 A. We always and consistantly figured an average flow of 150 gallond per capita per day; with the completed project in which a population of 1,600,000 persons were to be provided for, we figured an average sewage flow of 240 million gallons per day. In designing the main trunk sewer we took in consideration peak loads as regards sewage flow estimating them at approximately 50% in excess of the average flow for the day, or in round numbers we figured that during any particular short period in any particular day the maximum rate of discharge of the trunk sewer in 1940 would be 360 million gallons.

Q. That would include the entire amount of sewage and ten per cent of the trade wastes would it not?

A. We come back here to a point of law *a* upon which I am unable to give you a satisfactory answer, that is to say, as to the percentage of the total sewage flow which is to be made up of trade wastes alone.

Q. Are you still in doubt Mr. Johnson as to the mode of measuring the percentage of trade wastes to be taken into the Passaic Valley Trunk Sewer?

A. I am in doubt and am of the opinion that the wording of the law is somewhat ambiguous. I certainly believe that if the precise phraseology means that of all of the trade wastes of the Passaic Valley District only ten per cent of the same shall be allowed to enter the sewer that this is a restriction not only uncalled for, but in all probability not so meant. My interpretation of this clause as already set forth is that when the project shall have been completed, of the total volume of discharge from the Passaic Valley Trunk Sewer but ten percent of that volume shall be trade wastes, and no more.

Q. According to your interpretation of the laws of the State of New Jersey for 1907, chapter 10, which is an Act to provide for purification of the waters of the Passaic River, you would have to know what the entire volume of sewage discharge was before you could estimate the amount of trade wastes that could be ac-

3730 commodated. Is that right?

A. I suppose in a general way that may be considered to be correct.

Q. I will again direct your attention to the section of the law which is mandatory, relative to the percentage of trade wastes and

will ask you to follow me if you will with the copy of the report of the Passaic Valley Sewerage Commissioners for the year 1908 in which this law is set forth, under the Roman numeral "II", the second last paragraph on the page and the last paragraph in section 3.

"In preparing the maps, plans and specifications for the intercepting sewer or sewers, plant or works to be made by the said Commissioners as hereinafter provided and in ma-ing the estimate of sewage capacity required for each municipality re*ards* shall be had by the said Commissioners both to the area and population to be provided for, making provision however, for not more than ten percentum of factory wastes and excluding all wastes from gas-works and all substances and discharges which may injuriously affect the integrity of the sewer or sewers when constructed."

I now ask you Mr. Johnson if that section of the law of 1907, chapter 10 section 3, does not distinctly provide for the measurement of the percentage of factory wastes as 10% of the entire factory wastes, which is it be accommodated in that sewer, and that it is not in direct relationship with the sewage itself, as the standard of measurement for the amount of trade wastes to be accommodated in the trunk sewer?

Mr. Riker: Objected to on the ground that the section of the act speaks for itself and is to be interpreted by the court and not by this witness, and that in any event if the view suggested by counsel for the complainant is correct it will result in a less discharge of polluting trade wastes into the bay of New York than this witness has been estimating in his testimony and goes simply to the
3731 question of the efficiency of the plan as the Passaic Valley sewer district is concerned and does not in any way concern the complainant in this case.

The Commissioner: Note the objection of counsel for the defendants.

Dr. O'Sullivan: The question is pressed by counsel for the complainant on the ground that the measure of the trade wastes will materially affect the question of disposal and sewage treatment as to the efficiency and as to the character of the effluent to be discharged into New York Upper Bay.

A. I do not feel that I am competent to pass upon what is obviously a point of law. The statement, as I have said, is clear that in that provision is made for not more than 10% of the factory wastes, but it is conceivable that there might be some discussion over what is really meant by "factory wastes." The law is explicit in excluding gas wastes, therefore it is not without reason to suppose that "factory wastes" might mean one thing and "trade" wastes another thing.

Q. Do you make such a distinction Mr. Johnson?

A. I always have, yes, sir.

Q. How would you distinguish a factory waste from a trade waste?

A. I can conceive starch works, galvanizing works or tanneries

as not being factories; nevertheless they discharge *of* offensive trade wastes.

Q. How would you class those wastes you have just enumerated as factory or trade wastes?

A. I would classify them as trade wastes.

Q. In what description would be considered the factory wastes?

A. An example might be mentioned in the case of a hat factory, which also discharges offensive trade wastes.

Q. How many manufacturing plants along the Passaic River discharge factory wastes and how many trade wastes?

3732 A. I could not tell you because it is hard for me to separate in terms that would be understood and taken as standard. mills, and factories and other manufacturing establishments. I find, for instance, in Passaic, three woolen mills, one print works, one chemical works, one rubber factory, one brewery but I certainly should not call *a* brewery wastes factory wastes. The rubber factory is clearly designated.

Q. Are there along the Passaic River and discharging into the Passaic River *abbstoirs*, bleacheries, breweries, chemical works, coal washings, cotton mills, creameries, dairies, distilleries, *gye*-works, gas works, laundries, leather dressing works, paint mills, paper mills, paste-board mills, pulp mills, silk mills, slaughter houses, starch works, straw board mills, sugar factories, sulphate mills, tanneries, and woolen mills, as well as yeast factories?

A. Yes, I believe that all of the industries you have mentioned are represented on the line of the trunk sewer.

Q. Which of these, Mr. Johnson, would you classify as factories and as yielding or contributing factory wastes and which would you classify as yielding or contributing trade wastes?

A. It seems peculiar, if this is the point, and I think it undoubtedly, is, that *of* all these various industries are nor designated as factories, as in the case of sugar factories the class that discharge trade wastes and which certainly cannot be considered as factory wastes, I would name the abbat-oirs, breweries, chemical works, coal washings, creameries, dairies, distileries, gas works, laundries, starch works, tanneries and even yeast factories. The only eliminations that have been made which might or might not come under the factory class are the bleacheries, cotton mills, dye works, gas works, leather dressing works, paint mills, paste board mills, pulp mills, silk mills, straw mills, straw board mills, sugar factories, sulphate mills and woolen mills.

3733 Q. In the distinction between factory wastes and trade wastes a recognized distinction among sanitary engineers, Mr. Johnson?

A. I cannot at this moment recall any text book on the treatment of factory wastes; I can however recall standard works on the treatment of trade wastes.

Q. Does any work written by any engineer in any language in any country draw a distinction between factory wastes and trade wastes that you know of?

A. They may not and probably do not attempt to distinguish between them.

Q. Are you now making a distinction for the first time between factory wastes and trade wastes?

A. I am saying that in the case of a legal argument that point unquestionably would be considered very carefully in my opinion.

Q. I am asking you, Mr. Johnson, as a sanitary engineer, not as a gentleman versed in the law.

Mr. Riker: What are you asking him?

Dr. O'Sullivan: I ask you Mr. Johnson, whether you are making the distinction now for the first time between factory wastes and trade wastes?

A. No, sir, I do not think I am. I recognize that factory wastes may be trade wastes, but I do not recognize that all trade wastes are factory wastes.

Q. How do you distinguish them?

A. I have already set forth my views in as much detail as I am able to.

Q. Then as you interpret the laws of the State of New Jersey, chapter 10 of the laws of 1907, relating to the Passaic Valley sewerage project, you interpret that only provision is made for factory wastes, am I right?

Mr. Riker: The question objected to is objected to on the ground that that is what the law says, it is not the interpretation by this witness of it at all.

3734 The Commissioner: Note the objection of counsel for the defendants.

A. That is the only one that is specifically mentioned with the exception of the waste- from the gas works, which are explicitly excluded.

Q. Would the factory wastes or the trade wastes affect the integrity of the sewer as set forth and provided for in the Laws of 1907 of the State of New Jersey, chapter 10?

A. It is conceivable that certain trade wastes in sufficient volume might affect the integrity of the sewer.

Q. Which trade wastes or factory wastes would be likely to affect the integrity of the sewer?

Mr. Riker: The question is objected to on the ground that the witness has testified that factory wastes are less inclusive than trade wastes and that his attention should be directed to which particular designation the question is intended to apply.

The Commissioner: Note the objection of counsel for the defendants.

A. Such wastes as strong free acids, but the likelihood of their being acids in free form present in the sewage going into the trunk sewer is not good.

Q. My inquiry, Mr. Johnson, related to trade wastes and factory wastes, and I now ask if it is unlikely that the spent liquors would

contain acid wastes from either factories or from manufacturing plants that would contribute trade wastes to the trunk sewer?

A. Some of the industries undoubtedly discharge acid wastes but they are spent acids as a rule and not in their active state.

Q. Then from what character of factory or trade wastes would you expect the integrity of the sewer to be assailed?

A. From such observation as I have made I am of the opinion that none of the wastes which will enter the Passaic Valley trunk sewer will be present in sufficiently large volumes to affect the integrity of the trunk sewer.

3735 Q. Although the law provides for maintaining the integrity of the sewer against these trade or factory wastes?

Mr. Riker: The question is objected to on the ground that it contains a statement of a conclusion of law by counsel which is not in accordance with the statute and not warranted by any interpretation of the statute.

The Commissioner: Note the objection of counsel for the defendants.

(The question was read to the witness.)

Mr. Riker: You had better read the statute before you attempt to reply to that question.

A. I find a clause in chapter 10 of the laws of 1907 which states: *— "Exclude all wastes from gas works and all substances or discharges which may injuriously affect the integrity of the sewer or sewers when constructed."

The word "integrity" I believe to be capable of several interpretations; it may mean disintegration, it may mean diminution in capacity; it is without doubt not only possible but probable that due provision will be made by the authorities of the Passaic Valley District for the proper treatment of all trade wastes which enter the sewer in order to guard against both of those points and to comply with the law.

Q. What trade or factory wastes would you expect to assail the integrity of the trunk sewer even on your own description Mr. Johnson?

A. Of the wastes that are now being discharged in the Passaic Valley District the acids wastes are the only ones that I should look on with any apprehension and I do not believe that acids are present in sufficient quantities to affect the integrity of the sewer so far as its disintegritation is concerned.

With regard to the feature of clogging whereby the carrying capacity of the sewer would be diminished, sewages carrying large quantities of grease and solid matters in suspension might

3736 allow them to gather on the sides of the sewer and so ultimately affect the carrying capacity.

It is true that these things may be minimized before the sewage enters the trunk sewer, it is also true that in sewers of this size particularly it is no difficult matter to prevent the accumulation of deposits on the inner side of the sewer by systematic screening. So I see

no reason to be apprehensive that the integrity of the sewer would be affected by the discharge into it of trade wastes.

Q. Are there steel works in Paterson?

A. Yes sir.

Q. What are the pickling liquors that they discharge as trade wastes, in character?

A. They are composed very largely of hidrate of iron.

Q. Do they affect structures such as the trunk sewer unfavorably and to their disintegration?

A. When present in sufficiently large quantities they doubtless would.

Q. Do you recall an experience with acid wastes in the Bergen Hill which menaced the cement tubes put in by the railroad, and as to their disintegration by these acid wastes?

A. I do not. But I infer that the liquids flowing in the sewer *was* composed very largely of these wastes that you mention.

Q. And that they disintegrated the cement tubes?

A. It is possible that they would.

Q. What liquors will disintegrate concrete?

A. Strong acids.

Q. How will sugar solution affect them?

A. Through the fermentation of the sugar I can conceive of an action which would cause disintegration.

Q. How will glycerin trade wastes affect them?

A. Through the same agencies as I gave of sugar solutions.

3737 Q. How will gas and ammonia waters, as trade wastes, affect them?

A. The discharge from gas works is expressly prohibited in this case, as it usually is in all sewers, the wastes have a tendency to not only cause disintegration but also affect the carrying capacity of the sewer through the deposit on the inner side of the sewer of a tenacious film of tar.

Q. Are gas and ammonia trade wastes contributed by other factories and manufacturing plants than by gas works?

A. Ammonia liquors may be, but gas liquors I believe not, in any considerable quantity. Asphaltum works will probably contain some, rubber works might.

Q. How are the trade wastes from the gas houses in Passaic now discharged?

A. I don't know.

Q. Are you sure, Mr. Johnson, that they are not now discharged into the sewers?

A. It is possible that they might be, and if so it is not altogether strange, even though it is the worst practice that can be imagined; it is true of other cities as well as Passaic, I have noticed it in other places.

Q. How do ammonia waters disintegrate the cement or concrete including in ammonia waters ammonium sulphate, ammonium carbonate, as well as ammonia liquors?

A. I cannot tell you, but I can express the belief that such waters

will never be allowed to run waste in large quantities because of their value.

Q. Taking the producted of decomposition itself, do you know of any of the products of decomposition that would affect unfavorably, even to the extent of disintegration, the concrete lining of sewers?

A. I could express the belief that the most active disintegrating agents produced by the decomposition and putrefaction of
3738 sewage matters would be carbonic gas.

Q. Would not hydrogen sulphide disintegrate concrete much more rapidly and effectually than any of the agencies that we have now described in the questions and answers which have preceded this question?

A. If present as such it probably would; but it is also true in the case of virtually all sewages, in some more than others, that there is sufficient iron contained in the sewage to form a combination which the sulphura-ted hydrogen produced and the resultant precipitant is composed of iron sulphide which is in itself inert.

Q. Is the affinity or hydrogen sulphide, or as you have described it, sulphura-ted hydrogen, greater for the iron contents or for the constituents of concrete or cement?

A. I believe that they are more active in the case of the iron; I know that they are especiall- active in this regard.

Q. Do you know of any experiments along this line that have been reported by William M. Barr issued as a bulletin of the Iowa State College of Agriculture and Mechanical Arts, and by R. E. Buchanan of the Iowa State College, and reported in the engineering News of December 14th, 1912?

Mr. Riker: The question is objected to on the ground that it is immaterial and irr-levant, and this whole line of examination is objected to on the ground that it goes to the efficiency or propriety of the plan of the Passaic Valley Sewerage Commissioners, and has nothing whatever to do in any possible view with the question at issue in this case and is simply an attempt on the part of counsel to inject into the case criticisms of the judgment and plans of the Commissioners, without any reference to the issues.

The Commissioner: Note the objection of counsel for the defendants.

3739 A. I have read these articles, but my recollection of them is not clear at this time.

Q. Mr. Johnson, how do cocoanut oil and sugar affect concrete?

Mr. Riker: I desire to object to the question on the same grounds as last stated.

The Commisioner: Note the objection of counsel for the defendants.

A. I presume it affects in through the production of such compounds as result from the fermentation of those two articles.

Q. Is there any direct chemical union between the substances I have just named and any of the contents of the concrete itself?

A. I do not know.

Q. Let me draw your attention to the experiments of Mr. Furber, as published in the Engineering News for January 16, 1913, relative to the effects of cocoanot oil and sugar on concrete, and ask you if they have in any way conformed with your experience?

"I have found that the destruction action of the oil in converting the lime of the portland cement into lime soap is very rapid. By subjecting a sample of hardened concrete to the action of the oil for two weeks, the deterioration is very noticeable."

Have you had any such experience among your experiences?

Mr. Riker: The question is objected to on the same grounds as last stated.

The Commissioner: Note the objection od counsel for the defendants.

A. I have not, and the experiment is interesting only as showing the specific effect of a specific compound concentrated on con-
3740 crete. It does not represent conditions in any way near approaching those to be encountered in actual practice.

Q. Are cocoanut oil and sugar refuse among the trade contributions of the Passaic Valley manufacturing plants or factories?

A. I do not recall the cocoanut oil but the sugar mill I recollect distinctly.

Q. What in general is the effect of mineral and vegetable oils in trade wastes or factory wastes on concrete with which they come in contact in sewers?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I would not attempt to say, but I have seen many concrete floors thoroughly saturated with mineral oils which showed no visible signs of disintegration.

Q. Do they act differently in sewers where decomposition changes are taking place in their im-ediate viciniage?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I presume they might, but their volume bould be necessarily small as compared with the total flow of the sewage.

Q. What provision has been made by the Passaic Valley Sewerage Commis-ioners in thie project for a trunk sewer to exclude these factories and trade wastes that are likely to affect the integrity of the sewer?

Mr. Riker: The objection is objected to on the ground that it has not yet appeared in this case by evidence as to what character of sewer the Passaic Valley Sewerage Commissioners are proposing to build within the territory of the state of New Jersey, and that this question and this whole line of questions is based upon an assumption which has not been shown to have any existance in the case; I also object to it as immaterial and irrelevant.

3741 The Commissioner: Note the objection of counsel for the defendants.

A. I have seen no published reports setting forth the intentions of the officials of the Passaic Valley District in this regard; I presume, however, that there procedure at the time the trunk goes into commission will not be very different from the procedure adopted in other up to date sewerage projects, namely, to compel the various industrial establishments, where it becomes necessary, to install treatment works which are simple in design, inexpensive to build and economical to operate and in which will be removed from the wastes as discharged those parts which might in a raw state affect the integrity of the sewer.

Q. I understand you found no provision for such exclusion and for such treatment in the plant and specifications and reports submitted to you and which you collected data in reference to.

A. I have seen no such provision, but I cannot conceive of a condition existing here different from that condition in other places with which I have been connected in similar problems.

Q. What provision is made for the exclusion of the trade wastes if the 10% exclusion applies only to factory wastes?

A. Under the term of "Trade Wastes" I include all industrial wastes whether offensive or inoffensive. Provisions made in other places refer to the retension of grease and hair *nad* other suspended particles which might deposit in the sewer or on the sides thereof.

Q. Do you regard it as advisable to absolutely exclude all trade wastes or factory wastes that would menace the integrity of the trunk sewer itself?

Mr. Riker: The question is objected to on the ground that it is immaterial and irrelevant, and has nothing to do with the issue.

3742 The Commissioner: Note the objection of counsel for the defendants.

A. It is perfectly feasible to withdraw from the trunk sewer all the wastes of industrial establishments, but it is not called for, and would place these industrial establishments under an unnecessary burden, and for that reason I see no cause for such restriction.

Q. What provision is made by the Passaic Valley Trunk Sewer Commissioners for the disposition of the 90% trade or factory wastes that will not be carried in this trunk sewer?

Mr. Riker: The question is objected to on the ground that there is no evidence to support the assumption upon which it is based, and that it is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not accept the assumption that 90% of the trade wastes of the district shall be excluded from the sewers, I believe that to be a point which will have to be decided later.

Q. What percentage of the trade wastes, as you now understand the Passaic Valley Trunk Sewer Project, are to be excluded from the

intercepting or trunk sewer, and are to be disposed of otherwise than through the sewage disposal works to be situated somewhere on Newark Bay?

A. It is the present plan to take *take* into the trunk sewer all the offensive trade wastes of the Passaic Valley District; no trade wastes of an offensive character, with the exce-tion of gas house wastes, are to be excluded.

Q. And those that are excluded, how — they disposed of?

A. Those which are not taken into the sewer are composed of wastes in such a high state of dilution, that they may be safely discharged into the river without nuisance, with the exception as before stated of gas house wastes.

3743 Q. What disposition is to be made of the gas house wastes?

A. I know of no provision having been made as a matter of record, but it is probable that these wastes will be cared for on the premises by screening, sedimentation and filtration through beds of coke.

Q. Will screening and sedimentation eliminate the organic matters in solution?

A. Screening and sedimentation have some effect on the removal of dissolved organic matter in sewage.

Q. To what extent?

A. It is difficult to answer that question without first knowing certain set conditions with particular regard to the decomposition of the sewage to be treated.

The size of the screen and the velocity of the flow through settling tanks.

Q. Applying the question to the conditions as you are familiar with them for the sewage disposal of the Passaic Valley trunk sewer project?

A. The percentage of organic matter which will be removed be screening and sedimentation in the Passaic Valley project, or rather at the treatment works near Newark, will be subject to a considerable fluctuation, as has been found to be the case elsewhere. Experiments running over 11 months at Columbus show that the settling tanks did remove at times some of the dissolved organic matter not a large amount but some. In the case of the grit chamber set forth at page 77 of the Columbus report the average removal of dissolved organic matter, during the period of seven months, was very slight, the reduction being from 119 to 115 parts per million. In the case of the tank operating at high velocity from February to June the amount of dissolved organic matter contained in the effluent was two parts per million in excess of that found in the influent.

3744 Q. What kind of tanks were those?

A. Wooden tanks about 40 feet long.

Q. Are those the total dissolved organic matter?

A. They are the dissolved organic matter.

Q. Volatile or otherwise?

A. Volatile.

Q. What was the total of removal of dissolved organic matter?

A. That is the figure.

Q. What is that?

A. I have already given you that, the reduction from 119 parts per million to 115 parts per million.

Q. How was that removed, was it by screening, by sedimentation or by evaporation?

A. By sedimentation alone. I have no records to show the removal of organic matters in a dissolved state by mere screening.

Q. Were you consulting page 77 of the Columbus report then?

A. I was consulting page 77, yes sir.

Q. What does that heading in the tabulation appearing on that page mean, "residue on evaporation", and under which the figures you have just quoted appear, and under the sub-head "Volatile"?

A. In making these determinations it is the custom to use thoroughly clean platinum dishes having a holding capacity of about 130 cubic centimeters. These are thoroughly dried and weighed and placed in a desiccator; the sample is poured into this dish 100 cubic centimeters being the usual quantity and the dish is placed on a steam bath and there allowed to remain until the contents have entirely evaporated. The residue contained within the dish is obtained by again weighing the dish and comparing the
3745 weighing with the dish when clean. The difference represents the total residue of the evaporation. Another sample collected at the same time, or a portion of the sample already referred to, is run through a filter and all suspended matter removed. One hundred cubic centimeters of the clear liquid are then evaporated to dryness in a manner similar to that described above, and the total residue of evapoartion again determined. This determination represents the matter, on evaporation, which was in solution in the samples; the difference between the two represents the suspended matter. To determine the volatile matter, the dish after weighing is placed over a burner and read heat applied, usually in a radiator, for a short period of time, several minutes. The dish is allowed to cool and again weighed; the matters which are burned off and which are determined by again weighing the dish and subtracting that result from the previous results before heating, are termed volatile matters.

Q. Mr. Johnson, is any part of the sewage disposal project adopted by the Passaic Valley Sewerage Commissioners contemplating evaporation or filtration for the purpose of removing the dissolved organic matters?

A. I think not, no sir.

Q. My original question was what percentage of the dissolved organic matter would be removed by screening and sedimentation such as is contemplated to be put in use by the Passaic Valley Sewerage Commissioners?

A. I have already answered that by saying there would be some removed, and also by saying that it would be small. Unquestionably there are small quantities of dissolved organic matters which are drawn out of solution and attached themselves to the suspended matter and subside with it. These, as before stated, are small, and it is doubtful if they would amount on an average throughout the year

to more than 5% or so of the whole of the dissolved organic matter contained in the crude sewage.

3746 Q. In your experience is dissolved organic matter more or less putrescible than solid organic matter.

A. Organic matter in sewage which is in a dissolved state is putrescible, and highly so, as is also suspended organic matter present in sewage. It is a further fact that decomposition and ultimate putrefaction of the dissolved matters in sewage, take place more slowly than do the decomposition and putrefaction of suspended organic matters in sewage. It would be difficult to draw a line of comparison between the offensiveness or the putrefaction action on organic matters in suspension and in solution respectively.

Q. The distinction that I requested you to draw was between organic matter in solution and solid organic matter as to their relative putrescibility.

A. I thought I had answered that quite fully, but I will go further. Ordinary sewage contains a certain quantity of suspended matter, it is practically true that fifty per cent of this total organic matter is in a suspended state and fifty percent is in solution. The percentage of mineral matter in the dissolved organic matter is fairly well set forth in the Columbus report on page 77 and page 90. On page 77 in a grit chamber A, it is noted that the sewage applied to this tank contained two hundred and six parts per million of volatile organic matter of which one hundred and nineteen per million were dissolved. Similarly in the case of grit chamber B, the total amount of volatile matter in the applied sewage amounted to one hundred and sixty six parts per million, of which ninety-two per million were dissolved. On page 99 plain settling tank A, the sewage applied contained one hundred and sixty eight parts per million of volatile matter, of which one hundred and four parts were dissolved; in plain settling tank B the applied sewage contained one hundred and sixty four parts per million of volatile matter, of which one hundred parts were disolved. So that from

3747 these figured we can see that of the total amount of volatile matter contained in sewage approximately sixty per cent is in a dissolved state.

If we take similar result from suspended matters from the sample table, we find in the case of grit chamber A that in the applied sewage the total suspended matter amounted to one hundred and ninety six parts per million and the volatile matter to one hundred and eighty seven parts per million. Similer results in the case of grit chamber B show two hundred and forty-two and two hundred and seventy-four respectively. On page ninety in the sewage applied to plain settling tank A the total suspended matter was one hundred and forty seven parts per million of which sixty four parts per million were volatile. In the sewage applied to settling tank B the total suspended matter was one hundred and thirty four parts per million, of which sixty four parts were volatile. Therefore the amount of volatile matter in the solid matters amounted to about forty per cent.

Q. By volatile, do you mean organic matter in solution?

A. It is a rough determination of the amount of organic matter, yes, sir.

Q. Do organic matters go into solution in their passage through the settling tank?

A. I think not to any marked degree, although that would be true in the case of such matters as are deposited on the floor of the tank and there subjected to bacterial activities in which putrefactive conditions would be set up and maintained. Under such conditions as these in a layer of deposited sludge, the bacterial action would result in the hydroization and gasification of practically fifty per cent of the deposited matters.

Q. What gases would be evolved during such conditions as you have just described?

3748 A. There would be a large variety of gases, but they are principally marsh gases, and possibly some small quantity of sulphurated hydrogen, and maybe, probably, a considerable volume of hydrogen.

Q. How about nitrogen?

A. I suppose some nitrogen might be so evolved, but in the form of ammonia only.

Q. Do you regard sulphurated hydrogen as the most objectionable of sewerage products?

A. It is objectionable, highly so, if present in large amounts but it is true that in the practical operation of sewage work it is next to impossible to obtain a quantitative result as to the amount of sulphurated hydrogen evolved from a sewage tank; the amount is so small that it is only possible to get a quantitative result as a general proposition.

Q. Did you read the testimony given before the Harbor Line Board on the application of the Passaic Valley Sewerage Commissioners for a permit to tunnel under Newark Bay, under the Bayonne peninsula and New York Bay?

A. Yes sir, I read it.

Q. Do you recall a part of that testimony was that paint was blackened on the houses, that rivets were eroded on ships and that the metals on ships were interfered with?

A. Yes sir, I recall that.

Q. Will sulphurated hydrogen blacken lead paint?

A. It most assuredly will, even though present in very small quantities.

Q. So that it is a very deleterious product of decomposition is it not?

A. It is, but it is true as a rule restricted to deposited beds of such organic matter.

Q. It is evolved from the Passaic River at present, is it not?

3749 A. Through the putrefaction of the deposits on the bottom, yes sir.

Q. It is a case of daily and continual occurance, is it not?

A. It is.

Q. Do you regard it as the most obnoxious product of decomposition changes?

A. I do not think it is particularly objectionable except for the sense of smell; I have no doubt but what it would be regarded as objectionable in large quantities such as are now arising from the shores around New York and in the Passaic River.

Q. On which side of the river?

A. I do not think it attaches to any particular side of the river, I should say both sides, the East River and Harlem and Hudson.

Q. Are they worse on the Weehawken and Hoboken sides than on the New York side?

A. I have been traveling back and forth between Hoboken and New York for some years and it has been my experience that the offense is much greater on the New York side, as it naturally would be.

Q. Have you read the testimony of Mr. Fuertes taken in this present case?

A. I glanced over it.

Q. Do you recall what he described the condition to be in the Hoboken docks or slips or the piers?

A. I should be interested in seeing what he would say in the way of a comparison, I do not recall what he said specifically about Hoboken.

Q. What New Jersey cities contribute to the present condition of the lower Hudson and Upper New York Bay?

A. I suppose the most important are Weehawken, Hoboken, Jersey City and Bayonne.

2750 Q. What is the volume of trade wastes and of sewage contributed by the communities you have just enumerated?

A. I suppose the most reliable data are to be found in the reports of the Metropolitan Sewerage Commission, and I refer to the report of 1910, at page 76, in which the following appears:—

"There were ten cities in metropolitan New Jersey which had populations over twenty-five thousand, in 1905; the largest of these were Newark and Jersey City each of which had populations exceeding two hundred and thirty thousand. The total population of these ten cities was nine hundred and ten thousand in 1905, and will probably be at least one million seven hundred thousand, by nineteen hundred and forty."

Q. Can you make any estimate as to the relative quantities of sewage of trade or factory wastes contributed by these communities into the harbor waters?

A. There have been so many statements made as to the probable volume of sewage discharged into New York Bay at the present time, or more propoerly into New York Harbor, that I would only add another figure. The facts are I think they are altogether too high as they have been stated, they are out of reason; but referring again to the metropolitan sewerage commission report for 1910, at page 76, I find the following:

"The sewage produced in the Metropolitan District is discharged into the harbor either (a) Directly, near open navigable channels.

as in the case of New York, Yonkers, Jersey City, Hoboken, Bayonne and Elizabeth."

This is the first time I ever knew Elizabeth came into New York waters in the harbor.

"Or (*b*) indirectly into these channels by way of the rivers, as is the case with White Plains, Mt. Vernon, Paterson and Passaic."

"The total quantities of sewage discharged into New York Harbor per day, at the present time, are approximately as follows.

3751 In the East and Harlem Rivers three hundred and thirty five million six hundred thousand gallons; into the Hudson River 464,200,000 gallons; into the Upper New York Bay 104,000,000 gallons."

This is sewage said to be contributed by a total population in the metropolitan district, of five million three hundred and thirty-two thousand persons. This is about the lowest estimate that has been made and corresponds to a per capita flow of a hundred and thirteen gallons per day. Assuming, taking the data shown in the 1910 report of the Metropolitan Sewerage Commission, page 76, that the population of the contributing sources outside of New York City proper, is 1,332,000 this represents a total daily flow of 150,000,000 gallons.

I should say in round numbers that the sewage contributed by Weehawken, Hoboken, Jersey City and Bayonne is 50,000,000 gallons a day. That may be a bit low figure, but it looks reasonable.

Q. Does that include trade wastes as well as sewage?

A. Yes sir.

Q. Are there any more objectionable trade wastes contributed to the harbor waters than those from Bayonne?

A. It is certain that they are bad enough but probably the most offensive trade wastes which are discharged by the Passaic Valley District or New York City are the wastes from abat*b*oirs, of which there are twelve in New York.

Q. How many discharge into the Passaic River?

A. I do not recall that I have the exact number. There are less than twelve. That is as far as I can go.

A recess was then taken.

3752 Q. I do not think you gave me the total volume per day in gallons that you estimated the trade wastes would amount to for the year 1940?

A. As I have stated they have not been estimated; the facts are that the increase in the amount of trade wastes will not, in all probability, be in proportion to the increase in the total sewage flow in the future. A conservative estimate of the total volume of trade wastes of an objectionable character required to be taken into the sewer would be about twenty million gallons per day in 1940.

Q. That would be the total volume per day in gallons?

A. Yes sir.

Q. I asked you on Friday last if you knew how many pounds of silk were manufactured in Paterson in the silk mills, per year?

A. I do not.

Q. Mr. Hazen in his investigation as reported in the report of the joint committee on sewage disposal of the City of Paterson pages 69 to 70, says:—

"In the dye houses of Paterson are handled every year about seven and a half million pounds of raw silk, or two thirds of the whole amount manufactured in the United States. In handling this material the dyers estimate that one thousand gallons of water are used for every pound of silk, or for working days more than twenty million gallons per day, or two hundred gallons per capita for the entire population."

On that basis how large would be the trade wastes of the silk mills of Paterson?

Mr. Riker: The question is objected to because it states as a fact on which the question is based, matter which is not proved in the case.

The Commissioner: Note the objection of counsel for the defendants.

3753 A. The total amount of objectionable trade wastes from the City of Paterson, estimated in the year 1907, was 2,700,000 gallons.

Q. Per day?

A. Per day, in round numbers; therefore the amount of objectionable trade wastes approximate ten per cent of the total trade wastes of the city, placing this figure on Mr. Hazen's statement to which you have just referred.

Q. What would be the entire amount of trade wastes from the silk mills, either objectionable or unobjectionable, per year and per day?

Mr. Riker: If you know.

A. I can do no better that repeat Mr. Hazen's figures which you have just referred to, and which amount to 20,000,000 per day, or 6,330,000,000 gallons per year.

Q. And that 20 million gallons per day from the silk mills alone of Paterson is greater than the entire volume of sewage which you estimated would be discharged from the factories and manufacturing plants of Passaic Valley in the year 1940.

A. In the first place I want to call attention to the fact that in my last answer the yearly volume of total trade wastes from Paterson was figured on three hundred and fifteen working days. In answer to your last question I would say that the total volume of trade wastes from Paterson in 1907 as estimated by Mr. Hazen, is approximately the same in daily volume as that estimated for the entire Passaic Valley District in 1940. In the latter instance however, the total volume of trade wastes refers to objectionable trade wastes; in the case of Paterson in refers to objectionable and unobjectionable trade wastes, of which the former approximate ten per cent of the total.

Q. Will the objectionable trade wastes be among the ten
3754 per cent of the trade and factory wastes to be taken in the trunk sewer, or to be disposed of otherwise?

Mr. Riker: The question is objected to on the ground that it does not appear there is any ten per cent limitation on the waste to be taken into the sewer.

The Commissioner: Note the objection of counsel for the defendants.

A. In the case of Paterson, as in the case of all other communities, I have figured on taking into the trunk sewer all of the offensive trade wastes of the various communities.

Q. How much soap is used per pound of raw silk manufactured in Paterson?

A. You gave me that figure at the last meeting but I have forgotten it.

Q. "A pound or more of soap is used for every pound of raw silk a substantial proportion of which passes off with the wastes; a large amount of extractive matter or gum is removed from the silk." I now ask you if that matter is putrescible and whether or not it contributed in a substantial degree to the present polution of the river.

A. There appears to be little doubt but that the gum to which you have referred is putrescible, and that it does contribute to the offensiveness of the trade wastes as discharged; the further fact is clear, however, as stated in Mr. Hazen's report, that the total amount of this character of wastes is very small.

Q. Where do the silk mills get the twenty million gallons of water that they consume per day in the silk factories or the silk manufacturing plants of Paterson?

A. They obtain the bulk of this water from the Passaic River above the Great Falls, and from Private artesian wells.

Q. And that would average two hundred gallons per capita for the entire population would it not, as stated by Mr. Hazen?
3755 A. Yes, sir.

Q. Mr. Hazen further states:

"A considerable portion of the water used in the dye houses is ground water obtained from the gravel and rock under the city."

Do you know whether that is true or not?

A. I do.

Q. Is it so?

A. It is, yes. Those are what are known as artesian wells.

Q. Do you know whether or not various chemicals and dyes are used in the process of silk dying and if — will you name some of those chemicals and dyes?

A. I know that there are used in the silk dying industries certain chemicals and dyes such as logwood, tannin, and so forth, but I have not made a list of these chemicals, nor can I give it to you now.

Q. Taking the first operation of silk throwing, do you know whether olive oil and Neatsfoot oil are used in that operation?

A. I do not, I believe that they are; I know that olive oil soap is used largely in the silk dy-ing industry.

Q. Do you know what per cent of the weight of silk they would equal approximately?

A. No, sir.

Q. Mr. Hazen states it to be from one to ten per cent; have you any reason to doubt that?

Mr. Riker: The question is objected to on the ground that it is assumed if Mr. Hazen says so, and there is no proof of it.

The Commissioner: Note the objection of counsel for the defendants.

A. I presume that Mr. Hazen obtained his information from officials at the various silk mills, and presume that the data given by him were based upon facts derived from those sources.

3756 Q. Do you know whether or not this soap is wasted and at the *and at the* present time goes into the river or into the sewers according to the location of the mills?

A. It is probable that this soap is wasted and that it finds its way either into the sewer or into the Passaic River directly.

Q. Do you know whether that waste from the stripping or boiling off and the soaking of the silk in this strong hot solution of olive oil soap, and washing, is particularly impure and putrescible?

A. All greasy substances are more or less putrescible and objectionable.

Q. In the next operation, the bleaching, do you know what chemicals are used, in that operation and do you know whether or not sulphiric acid and hydrogen peroxide are among those chemicals?

A. I presume that they are, and particularly the sulphuric acid. The usual chemical used in bleacheries is chlorine gas.

Q. Is sulphuric acid injurious to concrete or cement structures?

Mr. Riker: The question is objected to on the ground that it is immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. If present in sufficient quantities I have no doubt that it is.

Q. In operating on the lighter shades of silk do you know whether they are weighed with tin and whether the silk is dipped alternately into solutions of stannous chloride and sodium phosphate, and finally passed through a solution of sodium silicate.

A. That is the usual method in the production of a large bulk of the silks of today; it is a development of the last hundred years or less, and has a great deal to do with the life of the product.

3757 Q. Do you know, Mr. Johnson, whether or not stannous chloride and sodium phosphate and sodium silicate are poisonous substances or not?

A. I believe that they are, some of them.

Q. Do you know what the dynamite bath consists in to which the silk is subjected to after the treatment embodied in my last question?

A. No, sir.

Q. Do you know what the red iron bath is to which silk goods are subjected that are to be dyed black and weighted?

A. I can give a guess, but I don't know.

Q. Do you know that after this operation the silk is again passed through a soap bath and then immersed in a bath of potassium ferro-cyanide of yellow prusiate of potash?

A. No, sir.

Q. Is potassium ferro-cyanide a highly poisonous substance?

A. Yes, sir.

Q. Do you know whether or not the silk after this treatment is immersed in a solution of hydro-chloric acid and after each of these processes the silk is washed and immersed in a bath of gambier and tin chrystals, and that some times catechu is used instead of gambier?

Mr. Riker: If you know, answer whether you do or not.

A. I do not.

Q. *You* you know whether or not these are highly poisonous substances?

A. I do not.

Q. Do you know that tannate of tin is used after the gambier bath and that gambier bath is entirely thrown away and containes both tin and tannate?

Mr. Riker: If you know.

A. I do not know.

Q. Do you know whether or not silk after these processes
3758 is given an organic weighing, and if so state what the organic weighting or weighing is?

Mr. Riker: If you know.

A. I do not know.

Q. Do you know that after this treatment the silk fabric to be dyed white are dipped in a solution of methyl blue, and after dying washed and passed through an acid bath and dried, that color dying is nearly altogether done by analine dyes and whether these substances are highly poisonous and injurious to concrete as well to the bacterial life expected to subject sewage to biological processes for its purification?

A. I have no knowledge of these processes and restate my opinion that many of these chemicals that you have mentioned are poisonous, but I have yet to be convinced that they are present in sufficiently large quantities to affect the integrity of the sewer; so far as affecting the bacterial contents of the sewage is concerned, it is possible that they may have some local effect as a germicide. In as much as it is proposed to make use — biological processes in the purification of the sewage of the Passaic Valley District this is a factor of no importance; if anything it would be in favor of the Passaic Valley Project in as much as such germicidal action tends to diminish the probabilities of putrefactive action taking place between the point of discharge of such wastes, and the outfall in New York.

Q. Do you know whether or not these spent dye liquors are wasted, and if so whether they are very impure and whether they contain

the soap and the silk gum which is boiled off and which renders these wastes particularly putrescible.

A. I know that the dye liquors, after they have spent their force are wasted, and I know that they are offensive and require to be taken into the trunk sewer. The proportion of these wastes
3759 to the total wastes from silk dy-ing establishments is relatively small, however.

Q. Do you know, Mr. Jhonson, whether with the method of black dy-ing which I have just described, silk when first weighted with red iron is subjected to a bath of gambier and tin and is immersed and washed in a solution of logwood which also contains a large percentage of soap and whether or not this bath after having been used, is wasted as it is foul and should be taken into the trunk sewer?

A. Your proposition sounds reasonable.

Q. Do you know whether or not this last process is followed by washing with wash water which is also exceptionally foul and that it should be taken into the sewer?

Mr. Riker: The question is objected to on the ground that it is at least double and the witness may be able to answer part of it and may not be able to answer other parts of it.

The Commissioner: Note the objection of counsel for the defendants.

Mr. Riker: The question is whether you know certain things, and then whether you conclude certain other things.

A. It is reasonable to assume that the first washing would be somewhat offensive and foul but that subsequent washings, and by that I mean a great many washings, in as much as the quality of the goods undergoing the process depends on thorough cleaning, are not sufficiently foul or highly colored to require that they be taken into the trunk sewer; they may therefore be discharged without offense into the river.

Q. Do you know whether or not the next step after the one I have described is to immerse the silk into a bath of pyrolignite of iron, or black iron as it is called, which serves as a mordant, after which it is washed again and that this wash water is foul?

A. I do not.

3760 Q. Do you know that after this mordanting the silk is then put into a bath of *bambier* and then into soap and logwood and once more washed and that the final part consists of immersing the silk in a bath of ascetic acid and lemon juice which gives it a scroop and makes it brilliant, and that this bath is wasted and should be put into the sewer?

A. I do not.

Q. Do you know that in jet black dy-ing the weighing is done with tin and silicate and the dy-ing with gambier and logwood, that sumach and nut galls are used, and that the liquor or waste from this first part and the subsequent wash waters are particularly foul and should be carried in the sewer?

A. I do not.

Q. Do you know that in the finishing, printing and final operation gum arabic, glue, starch, dextrine, and similar substances are used?

A. I so not.

Q. From these various operations that we have been describing do you know what the total solid and suspended matters amount to, and whether or not analyses would give 2.05 pounds of total solid matter per pound of silk.

A. According to my best recollection Mr. Whipple and Mr. Hazen stated in the report which you are now referring to that the total amount of spent dyes, wash water and other wastes from two hundred and ninety five establishments in Paterson amounted to 2,000,000 gallons daily. The amount of suspended matter in these two million gallons of offensive wastes which require to be taken into the sewer I have no data on, but I can figure it if you so desire.

Q. Please do so.

A. Mr. Whipple gave this figure as 11 tons of suspended matter per day as being contained in the trade wastes discharged from the silk manufactories, to the best of my recollection.

Q. Do you know Mr. Johnson, whether or not the seven
3761 and a half million pounds of silk dyed per year in the silk factories of Paterson yield thirteen and a half million pounds per year of total solid matter and but six million pounds of suspended matter or thirty seven thousand and sixteen thousand five hundred pounds per day respectively or one hundred and fifty-one and fifty-eight grams per capita daily?

A. I do not.

Q. Do you know what percentage of these solids is organic matter and what percentage mineral matter?

A. I do not.

Q. Do you know whether or not the amount of organic matter discharged from the dye works in Paterson, in the silk factories, is 8,100,000 pounds per year or 22,000 pounds a day or 90 grams per capita daily?

Mr. Riker: The question is objected — on the ground that the witness has already said he does not know.

The Commissioner: Note the objection of counsel for the defendants.

A. I could not check that without figuring.

Q. Do you know whether or not three fifths at least of this organic matter is in suspension and is composed of particles of such size that they cannot be removed except with filter paper?

A. I do not.

Q. Do you know what the organic matters in the silk wastes from Paterson silk manufacturing plants chiefly consist in?

A. Specifically no.

Q. Do you know whether or not they consist of soap, silk gum, waste organic dye stuffs, acids and such like organic compounds?

A. I believe they do.

Q. Do you know that the average weight of soap u*n*ded in Pater-

son is more than equal to that of silk, and that seventy five
3762 per cent of the soap may be recovered at the works where three and a half million pounds out of the total seven and a half million pounds of silk per year is dyed and that the amount of the other wastes from the dye works is found to be equal to 13,300 pounds per day or 54 grams per capita daily?

Mr. Riker: If you know, Mr. Johnson.

A. I do not.

Q. Do you know whether or not the silk gum amounts to twenty five per cent of the weight of the silk or about 5,100 pounds a day or 21 grams per capita daily?

Mr. Riker: The question is whether you know.

A. I do not.

Q. Do you know what the amount of wastes from the throwing mills are in the silk operations of the silk factories in Paterson?

A. I do not.

Q. Do you know whether one and a half million pounds of silk are thrown every year in addition to the matter we have been speaking of and that five pounds of soap are used for each one hundred pounds of silk and that the total amount of the soap used is seventy-five thousand pounds per year, or two hundred and six pounds per day, in those factories?

Mr. Riker: The question, do you know?

A. I do not.

Q. Do you know any other sewage districts in this country where ninety per cent of the trade or factory wastes is excluded from the sewers?

A. I do not.

Q. How many hours are required in warm whether for sewage to become mal-odorous in the sewers themselves?

A. It depends upon the quality of the sewage initially, the temperature of the sewage and its composition.

3763 Q. Can you give me an average or approximate as to the number of hours, taking sewage of the type of the Passaic Valley sewage?

A. Observations made along these lines in many hundred of samples led me to believe the opinion that a sample of sewage taken from an incepting sewer many miles in length and allowed to stand on a table at room temperature will become mal-odorous in something like twenty-four hours.

Q. Is the sewage likely to become mal-odorous in warm weather while passing through the settling tanks?

A. By reason of the fact that its retention period is one and a half hours as a maximum I feel no apprehension about its growing mal-odorous during its stay in those tanks.

Q. Is the sewage likely to become mal-odorous in warm weather while passing through the long outlet tunnel under Newark Bay and Upper New York Bay?

A. I have already expressed the opinion earlier in my testimony that it will not.

Q. If the sewage is mal-odorous before reaching the settling tanks will it become less so by passing through tanks and this long outlet tunnel?

A. There is a possibility of course that such possibly mal-odorous condition would be increased during its stay in the tanks during the period of time elapsing between its discharge from those tanks and its entrance into the waters of New York Bay. There is however, a possibility of the sewage, while remaining in those tanks, taking up oxygen from the atmosphere which might in some measure diminish these mal-odorous conditions inasmuch as in my opinion the sewage as it enters them and as it leaves them will not be truly septic.

Q. Do you know of any case where sewage has entered into combination, either by absorption or chemical action, with the oxygen of the air in passing through deposit tanks?

3764 A. I know it is a generally recognized theory that oxygen is so absorbed where opportunity is given to subject the surface of the sewage to the atmosphere.

Q. What are the relative capacities of sea and fresh water for absorbing offensive odors of sewage?

A. Generally speaking it is not possible for sea water to contain as much dissolved oxygen as fresh water, therefore its ability or power as a sewage digester is somewhat less.

Q. I was more particularly inquiring as to the relative capacities of sea and fresh water for absorbing the offensive odors that are given off by the sewage in the form of gases during putrefactive changes?

A. Opinions appear to differ in regard to that point, but inasmuch as Oxygen may be absorbed in the atmosphere and the opportunities for that oxygen so absorbed to diffuse throughout the entire vertical plane of the body of water under consideration are greater in the case of salt water than in the case of fresh water, — the evaporation feature plays an important part in the consideration of this question, whereby thorough evaporation, the top stratum of salt water becomes heavier and the air so absorbed is carried down with this heavier stratum as it sinks below the surface.

Q. Do you regard sulphura-ted hydor-gen, menthane and carbon dioxyde as gases devolved through putrefa-tive changes?

A. I do.

Q. Are they as soluble in salt water as they are in fresh water?

A. It is reasonable to suppose that they are not.

Q. Have you ever performed an experiment along these lines to determine the relative solubility of putrescent gases in fresh salt and brackish water?

A. I have not.

3765 Q. Are there other objectionable compounds to your knowledge like indol, scatol, phenol, oresonole, and phoephine found in sewage?

A. They are.

Q. Are those more or less soluible in salt or blackish water than they are in fresh water?

A. As I have already stated opinions differ on this point and I feel in answering this question I can do no better than to call attention to information on this line contained in the 1912 report of the Metropolitan Sewerage Commission pages 47-48 as follows:

The assimilation of sewage matters proceeds satisfactorily only so long as a supply of oxygen is available. When the oxygen becomes exhausted putrefactive changes set in and offensive odors are produced. These odors are particularly disagreeable when putrifaction takes place in sea water. In this case the demand for oxygen, which under ordinary circumstances are stable, are destroyed by the oxygen which they contain."

Another view is expressed by Dr. Addeney and contained in the fifth report of the British Royal Commission on sewage disposal, appendix 6, page 63; Dr. Addeny, who is recognized Internationally as an authority on this question, has the following to say:

"It must be concluded that the rates of carbon fermentation and of nitrogen fermentation in sewage matters were practically unaffected whether the sewage matters were mixed with sea water or with fresh water and kept under the given conditions and at temperatures between 15 degrees and 18 degrees centigrade, and that also the rates of absorption of oxygen by the sewage matters was similarly unaffected.

"It cannot be taken as generally proved therefore that fresh water presented any superiority over sea water in its capacity of bearing pollution within the limits of fouling. It is true that fresh water can hold 20 per cent more oxygen in solution than can sea
3766 water, temperature for temperature, and under actual conditions; but against this must be considered the fact that dissolved oxygen is transmitted through di-aerated sea water from the surface downwards about three times more quickly than through di-aerated fresh water.

"It has already been remarked that there seems to be a widespread impression that the odors from over-polluted sea water are more offensive than those from over-polluted fresh water. This impression is probably well-founded since sulphides and possibly organic sulphur compounds are formed in sea water when over-polluted by a reduction of its sulphates. We have not however, observed and offensiveness from sea water when polluted within the limits of fouling, that is so long as dissolved oxygen is present in it, any more that we have from fresh water when pollution within similarly restricted limits."

Q. How does the presence of oxygen in either fresh, salt or brackish water influence the solubility of either indol, skatol, cresonole, pfenol or hydrogen sulphide?

A. It is to be assumed that the solubility of the compounds you have mentioned would be reduced in general proportion to the oxygen contents of the water in which they were deposited.

Q. And if the oxygen contents was low you would expect those

substances to be evolved as mal-odor-us evidences of the sewage condition and its pollution?

A. It — my firm belief that these compounds you have mentioned can only be produced in layers of sludge where putr-active activities are at their height and that in all probability rising to the surface, they would be absorbed by the oxygen contained in the over-lying strata of water.

Q. Are those the only conditions under which they are produced that you know of?

A. I have paid particular attention to the prodection of such compounds, particularly in connection with studies of the differentiation and classification of bacteria and I believe that these are
3767 the main causes and sources.

Q. In other words you ascribe the production of indol, scatol, cresonole, phosphine and sulphurated hydrogen to an an-aerobic decomposition of sewage deposits, and to that source only?

A. I can conceive of no other condition and in this connection I would like to call attention to certain results obtained in the operation of certain coke strainers used in tests on purification of sewage at Columbus. (See report of Sewage Purification at Columbus, Ohio page 144). In this report I make the following comments.

"Septic action developed in both strainers soon after they were initially started and *preceded* therein with varying intensity until the beds were shut down for the last time. Although the beds were drained and allowed to rest for 12 hours each day on the regular schedule of operation, these rests, as well as others *were* several consecutive days were allowed, did not result in the destruction of this action in the beds, or even in a marked diminution thereof".

"At all times during their operation there was a pronounced odor of sulphure-ted hydrogen about the discharge pipes in the coke strainers. The cause of this was presumably due to the fact that the intimate contact under highly anaerobic conditions of the sludge in the coke layer and the applied sewage causing a formation of the gas from the decomposition of the organic matter present, and perhaps from the partial reduction of the sulphur in the coke and the sulphates in the applied sewage. The amount of hydrogen sulphide thus formed was in such relatively large amounts that the iron in the sewage and the sludge was insufficient to hold the gas as iron sulphide, as was probably the case in the septic tanks".

Q. Mr Johnson, you have now answered in relation to hy-
3768 drogen sulphide, what answer do you make relative to indol, scatol, cresonole, phenol, and phosphide?

A. It is my experience that these may be formed either in the presence or in the absence of oxygen due to the activity of facultative an-aerobic bacteria.

Q. Do you know of their deleloqment or creation under any other conditions?

A. That is all I have interested my self in.

Q. Would you expect to find them in fresh sewage?

A. I should not expect to find them in fresh sewage in quantities to be perceptible.

Q. Do you know whether or not sulphuretted hydrogen, indol, scatol, phenol, cresonole and phosphine are not formed in human intestinal tube?

A. I believe that they are and there unquestionably the cause is anerobic exclusively.

Q. So that you may have them in fresh sewage?

A. I hardly see the connection between you- last question and the present one.

Q. If they are formed in the *ailementary* canal of human beings how are they excreted from the *ailementary* canal of human beings if not in the excrements?

A. I should express that belief that as discharge from the human organization into water they are immediately absorbed by the oxygen which that water contains and so disappear.

Dr. O'Sullivan: Read the question.

(The last question was then read.)

Mr. Riker: Read the answer.

(The last answer was then read).

Q. Forming what compound?

A. That I am unable to say. I do know however that I have repeatedly made tests of sewage in an advanced state of decomposition as well as of sewage which has not decomposed, attempting to detect the presence therein of indol for example, and I
1769 have never found it.

Q. What test did you apply to determine the presence or absence of indol in fresh sewage?

A. The test prescribed by the Committee on Standard Methods.

Q. What is the result of discharging mal-odorous sewage into sea water with respect to the liberation of those odors?

A. If the sewage at the time of discharge contains volumes of offensive gases, the likelihood of their reaching the surface and there becoming apparent is to be measured by the diluting power of the water into which the sewage is discharged, with particular reference to the amount of dissolved oxygen which that sewage contains.

Q How can water dilute a gas?

A. Perhaps my answer was not any too clear. I meant by dilution, with reference to the possible disappearance of odors, the absorption of those odors by the oxygen which that water contained.

Q. Is such discharge into fresh water attended with a much less liberation of odors?

A. I think I can answer that question as well as I could previously by stating that opinions differ. Personally I think there is very little difference so long as the oxygen in that water is not completely used up.

Q. Who has made determinations on this point outside of the gentleman whose name you previously mentioned, Dr. Adeney?

A. I presume this has been made a subject for study by many laboratory workers; I am unable to state specifically who, to my knowledge, has done such work however.

Q. Have you ever read the experimental work of Kolkowitch?

A. I do not recall that I have.

Q. Have you ever read the experimental work done for the German Government by Professor Wilhelm on Brackish, Salt and Fresh water conditions?

3770 A. Most of my knowledge of European studies on such questions as these is restricted to the work of Dr. Dunbar of Hamburg, Calumette of Paris, Houston, Reddeal, Adeney and others.

Q. Have any of the men you mentioned outside of Dr. Adeney conducted any experimental work on brackish or salt water and sewage conditions?

A. I could not state positively that Dr. Dunbar and Dr. Kokowitch have, but I know that the three last mentioned, Houston, Reddeal and Adeney have done work on brackish water and salt water as well as fresh water.

Q. On what does the elimination of offensive odors from the body of water into which mal-odorous sewage is discharged depend?

A. It depends initially on the amount of dissolved oxygen present in the water, and secondly it depends upon the thoroughness with which the sewage containing these odors may be brought into contact with the oxygen of the water into which they are discharged.

Q. How much sulphura-ted hydrogen and these other offensive gases mentioned will one volume of fresh water absorb at normal baromet-ical pressure and 60 degrees Fahrenheit temper-ture?

A. I could not tell you off hand.

Q. Substituting "sea water" for "fresh water" can you answer the question?

A. I should presume about four-fifths as much as fresh water.

Q. Is the quantity of mal-odorous gases which a liquid can dissolve or absorb independent of the nature or quantity of other gases which it may already hold in solution?

A. I do not quite understand your question. A certain volume of sulphura-ted hydrogen gas may be made up of a number of gases, it may not be pure sulphura-ted hydrogen.

Q. Assuming that to be as you state, when will you answer

3771 the question?

A. I should be inclined to the belief that the demand upon the oxygen in that event would be lessened rather than increased.

Q. My question is directed to ascertain the quantity of mal-odorous gases which a liquid can absorb or dissolve independent of the nature or quality of other gases which it may already hold in solution Mr. Johnson?

A. Well, Doctor, I can only answer that question in this way:—The conditions that you presuppose are conditions that never obtain throughout any considerable period of time, they are conditions that are changing minute by minute, hour by hour and day by day; the result of today is not the result of tomorrow. In the body of water which we have under consideration, that is to say, Upper New York Bay, there are so many agencies of such a diversified character that come into play and control this whole

question, that to produce it to a precise science is out of the question.

Q. How many gases are held in solution by the brackish water that you found in New York Upper Bay besides sulphurated hydrogen?

A. I cannot tell you; I never made any analyses to determine that point.

Q. Do you regard skatol, cadaverin, mercaptan, and these other compounds that we were considering, as more or less repulsive that sulphurated hydrogen?

A. I expect it is all a matter of taste—or smell.

Q. In your particular case which do you regard as the most repulsive?

A. Well, I do not particularly like any of them, but probably indol is the most offensive; it is customary to consider the odor of indol is similar to a so called fœtal odor, but doubtless that so-called fœtal odor is caused by a combination of gases and not by any one alone.

2772 Q. Is there any provision made in the sewage disposal works of the Passaic Valley Sewerage Commissioners for the removal of these substances from the sewage to be treated at or near the Newark meadows?

A. We gave some consideration to the feasibility of removing these odors, should they be present, from the sewage before it is discharged into the bay. We were unable to find any feasible method for so doing that would come within reasonable cost. As a matter of fact, so far as I know, this is not done in connection with any sewage disposal project in the world.

Q. My question was for the purpose of determining whether or not any provision has been made for the elimination of these substances, in the sewage disposal scheme proposed by the Passaic Valley Sewerage Commission?

A. And I said, Doctor, that we found no feasible method; beyond that I do not know what the Passaic Valley Sewerage Commissioners propose to do.

Q. Do you attach some importance to the colloidal matters in sewage?

A. Yes sir, I do.

Q. What are colloids?

A. Colloids are sewage or other matters distinguishable from crystaloids, which are present in semi-solution or psudo-suspension.

Q. Do you make any distinction between mineral, vegetable or animal colloids?

A. Colloids which are usually found in sewage are what you would naturally expect them to be, organic.

Q. How do you distinguish organic from in-organic?

A. Organic substances may be made up of vegetable matter or animal matter.

Q. Is there anything in the organic kingdom that is not
2773 found in the inorganic kingdom, any one element?

A. The natural cycle of changes which starts with crude

organic matter, such action as starts with the fall of the leaf from the tree, carried through a cycle of changes, through the ammonia stages, through the stage of nitrous acid and eventually through the state of nit-ic acid which is salt peter and which in its turn serves as food for growing vegetable life and thereby completes the cycle; therefore you may say directly there is no element in the mineral kingdom that is not found in the animal kingdom.

Q. Have not recent experimental workers translated inorganic matters into organic compounds or compounds identical with non-organic compounds?

A. I believe that is so in the case of the production, of amesboids.

Q. How do you distinguish between colloidal matters and true solutions?

A. From the standard of the anazyist colloidal matters are those matters which are removable by filtration through media of very fine separations, like filter paper for example; a crystaloid will pass through, a colloid will remain.

Q. Name me some of the in-organic colloids?

A. Silica.

Q. Do you regard sulphate of antimony and arsenic and the hydrooxides or iron and illuminæ as in-organic colloids?

A. I do.

Q. Are these found in the trade wastes we have been discussing of the Passaic Valley Sewerage System?

A. I believe they are present in small quantities.

Q. Do you attach importance to these colloids, and their elimination from sewage effluents?

A. That would depen*t* entirely on the method of the disposal of the sewage if it were proposed to purify the sewage by
3774 screening sedimentation and biolytic filters, then I would consider those compounds, making sure that they were not present in sufficiently large quantities to interfere with the biological action in the filters. In this case where the stipulation calls for screening and sedimentation, I see no reason for withdrawing these wastes from the sewer.

Q. Will you name some of the vegetable colloids, Mr. Johnson, that you would expect to find in Passaic Valley sewage?

A. Bacteria.

Q. Any other?

A. Any organic matter derived from the vegetable kingdom which is present in a sufficiently finely divided state.

Q. Can you give me any of the textile fibers that yield colloidal matters and which you would expect to find in Passaic Valley Sewage?

A. It is possible that there will be found small fibers of matters from textile industries which are so finely comminuted as to remain practically indefinitel*t*, in suspension. Those are termed colloids.

Q. Do not flax, hemp, ramie and jute yield vegetable colloids and are they not used in manufacturing establishments along the Passaic River?

A. I expect they are, yes sir.

Q. Do not wood pulp of various grades yield colloids?

A. They do.

Q. Name some of the animal colloids that you would expect to find in the Passaic Valley sewage.

A. Any animal organic matter, or organic matter derived from some animal source is sufficiently finely divided to remain indefinitely in suspension I would regard as an animal colloid. It is further more claimed that grease, in an emulsified state might be termed an organic animal colloid.

Q. Do the elimination of these colloidal matters and of
3775 organic matters in solution usually interest and offer problems to the gentlemen who undertake sewage disposal?

A. They do, but more particularly in connection with the complete treatment in which biological filters are made use of.

Q. Do the colloidal matters rapidly absorb oxygen?

A. Not very rapidly, no sir; by no means as rapidly as organic matters in solution; the reason is obvious, it is impossible to bring the entire body of the colloid in contact with the oxygen.

Q. Can colloidal matters be removed by screens?

A. Some of them.

Q. Which ones?

A. I think there is no selective action, such particles in a colloidal state as naturally would stick and adhere to larger particles known as true suspended matter can be so removed.

Q. Can colloidal matters be removed by sedimentation and do you regard them as *sub*sidable parts of sewage?

A. In the sense that I have just — forth I do. As a particle of suspended matter subsides to a vertical plane it naturally comes in contact with finer particles which do not so subside and those particles naturally sticking to these larger particles increase their specific gravity and in a large measure accelerate the subsidance of the original particle.

Q. Do you know of any author who has put in print the very thin-s which you have just now testified to, that colloidal matters are subsidable or that they can be removed by screens?

A. I think it is a truism in filtration practice.

Q. Screening I said, not filtration.

A. On page 39 of the Columbus report on sewage purification the following appears under the head of "colloidal matter."

3776 "From a broad practical standpoint colloidal matters may be defined by plain subsidance in a reasonable and economical period of time. Suspended matters of this class are obviously in a very fine state of division and appear *and appear* to exist in a state of pseudo solution of micro-solution".

Q. Is that your definit*at*ion, Mr. Johnson?

A. Yes sir.

Q. You have a copy of Mr. George W. Fuller's book here, have you not?

A. Yes sir.

Q. Will you turn to page 394 and find that the identical words used by Mr. Fuller have not now been read by you?

A. They have but the further statement is made by Mr. Fuller: "This general phase of the composition of sewage was outlined in the Columbus Report of 1905 on pages 39 and 40 as follows".

Q. Is that definition yours or is it Mr. Fuller's?

A. It is entirely mine. Shall I continue?

Mr. Riker: Have you finished your answer?

The Witness: No sir.

Mr. Riker: Then go on.

The Witness: "Such a broad definition of colloidal matter allows various conceptions as to that portion of the suspended matters in sewage which shall be so classed. These so-called colloidal matters are obviously a fun-tion of both the velocity of sewage flow and the period of subsidence".

"Viewing this question of colloidal matters in a rough practical way,—not in the precise terms of the physical chemist—several interesting observations were made in regard to the local sewage".

"Speaking generally, it appears that the Columbus sewage ordinarily contains in the neighborhood of 50 parts per million
3777 of suspended matter which can be removed by subsidance only in parts and with great difficulty in practice. In bottle observations figures one-half of the above have been noted but on the other hand, when the sewage was strong, it seemed hardly possible to reduce the suspended matter by subsidance to 50 parts".

Q. In this Columbus report you dealt entirely with fresh water conditions, did you not?

A. Yes sir.

Q. How do harbors or bays or estuaries where there is a large mixture of salt water and the water is brackish; how does that effect these colloidal matters when they are discharged into it?

A. Bottle experiments conducted by the Massachusetts State Board of Health in Connection with the Charles River Dam inquiry some years ago demonstrated the fact that sewage as discharged into salt or brackish water was subjected to a precipitating action of the salt in the salt water.

Q. What per centage of the dissolved organic matter in sewage is colloidal?

A. I dislike to refer to my own work too much but I would like to call attention to the fact, which you may not be aware of, that these Columbus experiments were conducted in a more thorough manner and on a larger scale than any experiments on the disposal of sewage which had been conducted up to that time and which I believe have been conducted since that time; therefore I consider these results to be virtually standard even though they were obtained under my supervision and direction.

With regard to your question I desire to say that at Columbus we found that of the residu-m suspended matter contained in the effluent of settling tanks, which was supposed to be or considered to be
colloidal matter, one-half, or 25 parts to the million, was
3778 organic colloidal matter. With 25 parts colloidal matter to start from you may refer to page 28 of the Columbus Report

and there the average sewage is shown to contain a total of 215 parts of suspended matter. Therefore the amount of organic colloidal matter remaining in this sewage after sedimentation was about in round numbers 15 per cent of the total suspended solids contained in the Columbus sewage.

Q. Was the work at Columbus continued by anyone after you had severed your connection with it?

A. My work was done at Columbus, Ohio, incident with the design of the works, but more specifically the design was commenced after the test had progressed sufficiently far to allow final decision to be reached as to the type of works which it would be most advisable and economical for the city to adopt. With the close of the experiments in November 1905 the design of the sewage disposal works was still under way and every important feature had been decided upon. I know of no additional work in connection with the disposal of sewage which was done after my departure from Columbus on November 10, 1905.

Q. Have you read Mr. Hoover's report for 1911?

A. Mr. Hoover's reports refer to the practical operation of the works as finally built, and not to ant results which were obtained in the testing station of which I had charge and from the results of which the works were designed and later built.

Q. Does his report on the percentage of purification measured by the oxygen consumed in any way differ from the report you made in 1905?

A. That I am unable to state, although I should not think it strange if it did. The oxygen consumed determination is about the most erratic and unreliable test in sewage disposal that there is.

Q. The highest purification you got there was 35 per cent was it not?

3779 A. So far as the removal of suspended matter was concerned?

Q. Yes.

A. I believe that is substantially so.

Q. And didn't he find it by the oxygen consumed, that that should have been expressed in terms of 28 per cent?

A. I do not care to criticise Mr. Hoover's technique but would call attention to the fact that if he determined the efficiency of the septic tanks by the oxygen consumed result, determined from the crude sewage initially, and in the effluent of the septic tanks, in my opinion it is not possible to draw conclusions for the reason that true oxygen consumed results under such conditions and with such effluents are of little value, being complicated by compounds which are constantly rising from the bottom of the tanks through the overlying strata and passing away in the effluent; I would give no weight to the oxygen consumed determination as shown definitely and positively the efficiency of a tank operated as the Columbus tanks are operated.

Q. Did you find whether or not, in operating the Columbus plant and during this experimental period the larger particles of sus-

pended matter were more, or less, putresible than the smaller particles of suspended matter?

A. I did determine this point, which is of some significance in connection with the operation of the grit chamber during the first seven months of the test. This so called grit chamber was operated so that the sewage had a period of retention of one and a half hours. During that retentive period and with these low velocities of about one tenth of an inch per second——

Q. What page is that?

A. Page 79.—The deposits instead of being mineral in character as we had anticipated, were largely composed of street sweepings of which of course horse manure played a very important part; these sweepings were composed of large particles of suspended mat-
3780 ter. The tank was continually exploding, as we call it, that is to say these organic matters deposited being for a large part horse manure underwent active putrifaction and came to the surface with the ebullition of gases and so affected the result that we had to shut down the tank and provide a shorter period of flow. In this instance it is clear that the deposit of these large particles, composed as I have said of horse manure, were the responsible agents in our opinion for the speedy putrifaction of the deposits in those tanks.

Q. Then did you conclude that the smaller suspended particles were more putrescible than the larger suspended particles?

A. We concluded from that set of results that this particular suspended matter was very putrescible.

Q. The larger or the smaller?

A. These were the largest particles this sewer contained.

Q. Do you know whether or not Mr. Clarence B. Hoover, in 1911, reports a very different finding after continuing experimental works in the Columbus tanks?

A. I have no knowledge that Mr. Clarence B. Hoover operated the testing station at Columbus; such result as he obtained to the best of my knowledge and belief came from the main works as built later on.

Q. Have you ever read his report for 1911?

A. I get them consistently, yes sir.

Q. Do you know whether or not he found:

"The larger particles of suspended matter contain less putrescible matter readily undergoing bacterial decomposition than is the case with the more finely divided particles"?

A. That is not strange but it is a problem of some size to me, in the face of your statement, to reconcile the conditions in New York Harbor at present, wherein only the heavier particles have subsided and where those heavier particles undergoing putrifaction have been and are unquestionably the main cause for the
3781 unsatisfactory condition in New York Harbor today.

Q. Have you read the report of Mr. Ledderer of the Chicago Testing Station for 1911?

A. Dr. Ledderer?

Q. Yes, on the same line of experimental work as to the putrescibility of the larger or smaller of the suspended particles?

A. I have glanced it over but I have not read it with care.

Q. Do you know whether or not Dr. Ledderer's experiments conform in every particular with the findings of Mr. Hoover at the Columbus plant that the finer suspended particles are more putrescible than the larger suspended particles in sewage?

A. I do not know that.

Q. Are colloidal matters subsidable in sedimentation tanks?

A. Unquestionably.

Q. Let me direct you to page 24 of Mr. Fuller's book, the paragraph beginning with the words:—

"Parts of the suspended matter will float, parts will subside and part is so finely divided that it will not respond to the laws of subsidation or floatation; other solid matter will dissolve in sewage and form what is spoken of as crude solution as distinguished from colloidal matters. In sewage work 'colloidal matters' is used rather loosely; I mean those suspended matters in a state of very fine division which cannot be removed by sedimentation. In practice they exist in pseudo solution or micro-suspension."

"About sixty out of two hundred and ten parts of total suspended matter could not be practically removed except by filtration or by the aid of coagulants. Suspended matters in sewage may be divided into floating materials which form scum, subsidable matters, which forms sludge, finely divided particles which pass through
3782 all screens and sedimentation basins and which are spoken of as non-settling solids, as non-subsidable solids, as colloidal solids, or as solids unresponsive to subsidation."

I ask you if that quotation I have made from page 24 of Mr. Fuller's books, conforms with your experience as to the non-sedimentable and non-screenable condition of colloidal matters?

A. It does precisely. But you have rather passed over the broad point upon which you questioned me in your question preceding your last one. You asked me if colloidal matters could be removein sedimentation basins?

Q. Yes.

A. I said that they undoubtedly could be; if those basins were long enough and if a period of subsidance was long enough and the velocity of flow was low enough, they would unquestionably subside in time. Mr. Fuller is very clear on that when he states that——

Q. What page?

A. Page 24, what you've just read:—

"In sewage work the expression 'colloidal matters' is used rather loosely; I mean those suspended matters in a state of very fine division which cannot be removed by sedimentation in practice."

I underscore the word in practice."

Q. Such devices as the Passaic Valley Sewerage Commission has submitted to your study and on which you have expressed your opinion, will they remove the colloidal matters to be found in the Passaic Valley Sewage?

A. As I have already said they will remove such colloidal matters as naturally adhere to the larger particles of true suspended

matter in the course of the passage of those larger particles of suspended matter down through the liquid in the tank; the removal, it is true, of colloidal matters will be small by the devices stipulated.

3783 Q. How small?

A. That is impossible to state precisely but it is possible to conceive of conditions whereby these suspended matters will be coagulated by certain trade wastes w-ich may be found in the sewage and so aggregated in larger particles which will subside.

Q. Do you attach much reliance on the amount of work to be expected by the sedimentation tanks as designed by the Passaic Valley Sewerage Commissioners, or rather adopted by them?

A. Such tanks as are stipulated, which will be several feet long in which the velocity of flow will not exceed 75/100 of an inch per second, I consider will remove a substantial proportion of suspended matters, contained in the Passaic Valley Sewage.

Q. Discharging how much by way of effluent, what per centage?

A. About one half.

Q. Where do you expect the sewage disposal works to be installed?

A. I understand that these works are to be installed on the line of the sewer below Newark.

Q. Has any definite location been indicated to you?

A. I think that the location was pointed out but I do not recall where it was. As I understand it is subject to change.

Q. Has any provision been made in the plans submitted to you for the sewage disposal works to increase the size and capacity of those works?

A. No sir.

Q. How many outlets are there from the Passaic Valley Trunk sewer as it leaves Paterson and between that point and reaching the disposal works, that will allow a mixture of sewage and storm water and trade wastes to escape into the Passaic River?

Mr. Riker: The question is objected to as immaterial and
3784 irrelevant and being on matters that does not concern the complainant or its counsel.

The Commissioner: Note the objection of counsel for the defendants.

The further taking of testimony on behalf of defendants was then adjourned until Thursday February 20th, 1913, at 10:30 A. M., at the office of Messrs. Riker and Riker, Newark, N. J.

3785 The Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker and Riker, Newark, New Jersey, February 20th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esquire, Attorney General of the State of New York; William A. McQuaid, Esq., Deputy Attorney; Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.

Edmund Wilson, Esq., Attorney General of the State of New Jersey; Robert H. McCarter, Esq., of Counsel for the State of New Jersey; Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

GEORGE A. JOHNSON resumes the stand:

Cross-examination by Dr. O'Sullivan resumed:

Q. (Last question read to witness.)
3786 A. I don't know.
Q. Are there more that fifty, Mr. Johnson?

Mr. Riker: I enter the same objection as last recorded.
The Commissioner: Note the objection of counsel for the defendants.

A. I have no precise knowledge.
Q. What is the object of these outlets, for what purpose are they designed?

Mr. Riker: The question is objected — as last stated.
The Commissioner: Note the objection of counsel for the defendants.

A. I presume that you refer to storm water overflows which become operative at times of heavy rain storms when the capacity of the sewer would be exceeded.
Q. You do then let the storm waters into the Passaic River and into Newark Bay?

Mr. Riker: I make the same objection.
The Commissioner: Note the objection of counsel for the defendants.

A. I have no knowledge of this feature.

Q. What provision is made for the separation of storm waters, sewage, and trade and factory wastes that are to be allowed to be discharged through these outlets into the Passaic River and into Newark Bay during a period of storm?

Mr. Riker: The question is objected to on the ground that it contains an assumption of fact which this witness has not testified to and on the ground that it is immaterial and irrelevant in any event.

The Commissioner: Note the objection of counsel for the defendants.

A. I have no knowledge either of present arrangements of the sewer in this regard nor as to possible future arrangements.

Q. Do you know whether or not such arrangements exist
3787 in the present plans and specifications of the Passaic Valley Sewerage Commissioners?

Mr. Riker: He has just said he did not, and I do not know why you want to keep on questioning him when he just this moment said he did not.

Dr. O'Sullivan: I did not so understand it.

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I know that the existing sewers discharging into the Passaic River are in some cases sanitary sewers that is, sewers designed to carry only domestic sewage, and in other cases they are built on the combined plan, that is, they are designed to care for the domestic sewage storm water and other wastes which may naturally drain into them.

Q. When these sewers are connected with the trunk sewer or intercepting sewer what provision is made for the escape of storm water during the period of storm?

Mr. Riker: I make the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I have no knowledge of any provisions of this sort which may have been made or may be made in the future by the Passaic Valley Sewerage Authorities.

Q. Did you examine the plans of the Passaic Valley sewerage Commissioners for this trunk sewer during this month of February?

A. I spent about fifteen minutes glancing over the plans, which was too short a time for me to form any reliable idea of the features of design of the same.

Q. Are the first washings during the period of a storm particularly offensive and putrescible?

A. They usually are and these first flushings are made so by the

large quantities of street wash which contains much horse
3788 manure which form no inconsiderable part of the suspended solid matters in sewage which are relatively large in size of particles and which deposit at high velocities.

Q. Where storm waters are provided for to be allowed to escape from a trunk sewer are the arrangements automatic or otherwise?

A. They are automatic.

Q. How many of these automatic devices whether you call them outlets or by passes, are provided for in the Passaic Valley Trunk Sewer Project between Paterson and Newark?

Mr. Riker: I make the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not know.

Q. What is the calibre of the trunk sewer as it comes through Newark on its way to the sewage disposal works?

A. That may have been changed since the plans were prepared in the office of Hering and Fuller in 1907; of that I am not certain. If you wish me to do so, I will look up this point. I have, in what I believe to be a copy of the report of the Passaic Valley Sewerage Commissioners, a statement that the sewer under Newark Bay from the pumping station to the outfall, consists of the following—(Interrupted).

Q. My question was directed to the calibre of the trunk sewer before it reaches the disposal works.

A. I am unable to state that.

Q. Is it over thirteen feet in diameter, Mr. Johnson?

A. I should assume that it was for the reason that the tunnel under Newark Bay is given as twelve feet in diameter and the tunnel across Jersey City is given as 12 feet in diameter and the tunnel under Newark Bay is given as 12 feet in diameter, therefore I should assume that the size of the main outfall sewer as it enters the
3789 treatment works below Newark is in the neighborhood of 12 feet in diameter.

Q. Where are the sewage disposal works to be located, Mr. Johnson?

A. I have no knowledge that the precise location has been fixed, but know that it is to be located on the line of the trunk sewer below Newark.

Q. How near to Doremus Avenue if you know?

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. I can give you no more precise information regarding the location of the treatment works than is contained in my last answer.

Q. Where is the pumping station, to be located at the sewage disposal works?

A. I do not know but I presume it will be located at the outfall of the main trunk sewer and at the treatment works.

Q. How many pumping stations will form part of this Passaic Valley Trunk Sewer Project along its course?

Mr. Riker: The question is objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. I had nothing to do with this phase of the problem and therefore am unable to state of my own knowledge. There are according to the data I have before me some eight or more.

Q. Does the discharge of sewage through the pumping stations, these eight pumping stations, aid in comminuting the sewage and making more of the organic matter suspendable?

A. In a broad sense that may be true.

Q. How many connections through inverted syphons are made with the trunk sewer itself, the trunk or intercepting sewers on its way between Paterson and Newark.

3790 Mr. Riker: The question is objected to for the same reason last stated.

The Commissioner: Note the objection of counsel for the defendants.

A. I had no part in this feature of the Passaic Valley sewage project, therefore I am unable to answer of my own knowledge.

Q. From your studies of the Passaic Valley Sewerage Commissioners plans for the disposal works, will you describe these disposal works and as near as you can their location?

A. In the first place I did not interest myself in features of design when I examined the plans in the early part of this month, it was more out of curiosity than any thing else that I looked at them at all. I had intended, and I have followed this decision throughout my testimony, testifying in the light of the stipulation set forth in the agreement between the Federal Government and the Passaic Valley Sewerage Commissioners.

Q. Did the plans and specifications that you examined in 1913 in any way differ from or did they conform with, the plans and specifications as familiar to you and designed by the firm of Hering and Fuller?

A. Not having carefully compared the present plans with those prepared by Messrs Hering and Fuller in 1907 or thereabouts I am unable to answer this question.

Q. Would it be necessary for a sanitary engineer in passing upon the efficiency of a plant, to be familiar with the plans and specifications?

A. In general that is true, but with certain fixed conditions such as are set forth in the stipulation, nothing further is required in my opinion.

Q. What are the fixed conditions in the stipulation which influence your opinion and upon which is it based?

3791 A. The fixed conditions set forth in the stipulation complainants' exhibit No. 135. Under article first it is set forth and stipulated and agreed that the:

"Sewage, waste and other matter passing through the said trunk sewer shall first pass through course screenings to remove therefrom all large floating matter, and after passing through such course screens shall pass through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage or other matter shall pass through self-cleansing mechanical screens having clear openings of not over 4/10 of an inch".

Another fixed condition as set forth in the stipulation of complainants' exhibit number 135 is that the sewage after passing the fine screen shall be passed through sedimentation or settling tanks consisting of number of units each approximately 225 feet long and fifteen feet deep; the tank capacity to be such that there shall always be provided a detention period of not less than one hour at the maximum rate of flow of the sewage and a detention of not less than one and a half hours under the average condition of daily flow of such sewage, and that the mean lineal velocities through the sedimentation tanks shall not be over 5/10 of an inch per second for average flow, or ¾ of an inch a second for maximum flow. In addition to the above fixed conditions and in connection with these basins, scum boards are to be provided to retain the floating matter and proper and adequate devices used for the removal of the scum and deposit retained in the settling basins.

The next fixed condition is that the sewage after having undergone this treatment shall be pumped through a tunnel to a point in New York Bay near Robbins Reef Light and there dispersed into the waters of the Bay through a series of outlets discharging forty feet or more beneath the surface of the water at mean low
3792 tide.

Another fixed condition is the dispersing grid, which according to the stipulation shall be made by connecting the end of the tunnel with four or more discharge pipes extending across the current placed about 100 feet apart, laid in trenches on the bottom of the Bay and of a size decreasing in diameter from about six feet to two feet; on the top of these discharge pipes there will be a series of not less than 150 tees of a diameter not exceeding one foot and placed approximately ten feet apart. On each of the vertical tees outlets are to be placed and these outlets are arranged so as to discharge horizontally across the current, and the extent of the dispersion area is to be at least 3½ acres of the bottom of the Bay.

These are the fixed conditions from which I have drawn and am drawing, my conclusions in the testimony given by me in this case.

Q. Have you now stated your full knowledge of the sewage disposal scheme or design or plan adopted by the Passaic Valley Sewerage Commissioners for the disposal of the sewage to be conducted in the Passaic Valley Trunk Sewer or intercepting sewers?

A. I have.

Q. What kind of an effluent would such treatment produce?

A. I think I have already testified to the fact, in my belief, that as discharged the sewage will not be normally in a septic condition, at least not highly septic, probably just near the border line. I believe that some of the time the sewage as discharged will actually contain dissolved oxygen; I believe that — the total suspended matters in the crude sewage as received at the sewage works not more than 50 per cent will remain in the sewage as discharged in New York Bay, and furthermore, I believe that of the fat which the
3793 crude sewage originally contains not more than 50% will *still* be contained in the sewage as discharged in New York Bay, and that the fats which remain in the effluent as discharged will be emulsified and of practically the same specific gravity as the sewage containing them, hence their tendency to rise to the surface of themselves and form a slick on the surface of the water, is not good.

Q. How is that effluent to be conducted from the pumping station at the sewage disposal works into New York Harbor.

Mr. Riker: Objected to as immaterial and irrelevant.

The Commissioner: Note the objection of counsel for the defendants.

A. I understand it is to be conducted through a pressure tunnel.

Q. How is that tunnel to be constructed?

Mr. Riker: I make the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I do not know whether any changes have been made from the original plans of Hering and Fuller, therefore any statement of mine in this connection would be of small value.

Q. Do you know whether the tunnel is to be through rocks or whether it is constructed of masonry or iron or steel pipes or other material?

Mr. Riker: I make the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. As I have already stated, my part of this work did not embrace features of this kind.

Q. Where the matters I have embodied in my last question in the plans and specifications submitted to you in this present year of 1913?

Mr. Riker: I enter the same objection.

3794 The Commissioner: Note the objection of counsel for the defendants.

A. I do not recall that I gave ever seen the specifications, and neither the plans or the specifications were submitted to me for examination; I requested that I be given the privilege of glancing over them, which I did during a period of some 10 or 15 minutes.

Q. Whose plans and specifications were submitted to you in 1913?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I have no knowledge for the reason that the name of the engineer in chief, nor of the designer, did not appear on these plans according to my recollection.

Q. Do you know whether or not the present plans and specifications that were submitted to you in the year 1913 conformed with the outline planned as disclosed in complainants exhibit number 135, on which you state you base your opinion?

A. From what I saw of the arrangement for screens and the general layout of the various tanks, I believe that they do.

Q. Do you know of any where that sewage is disposed of through multiple outlets such as are proposed by the Passaic Valley Sewerage Commissioners?

A. I do not and consider it a refinement, and a vast improvement over methods which have been suggested up to this time.

Q. Has any similar mode of disposing of sewage ever been adopted anywhere that you know of, and then put in operation?

A. I would not attempt to say off hand.

Q. What objection would there be in your opinion, Mr. Johnson, to discharging the effluent produced under the plans as outlined in Complainants exhibit number 135, into Newark Bay?

3795 Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. To begin with, as I think I made it clear, that my testimony in this case has been very largely based upon fixed conditions contained in the stipulated agreement, I find in that stipulation no reference to the discharge of Passaic Sewage treated or untreated into the waters of Newark Bay.

Q. Could the effluent that would be produced and which you have testified could safely be discharged into New York Bay, be discharged without offense or nuisance into Newark Bay?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. Under present conditions where the Passaic River receives virtually all of the sewage which could at this time be naturally made tributary to the trunk sewer its digestion in the waters of Newark Bay and the Kill von Kull appears to be quite complete; it is certain that with the exception of such new sea water as enters upon New York Bay through the Narrows, the waters of Kill von Kull, at present polluted by the waters of the Passaic River are purer and in a better position adequately to dilute and digest sewage than any other waters entering the harbor. It is not improbable that the effluent from the treatment works could be discharged into Newark Bay, and for some time at least create no nuisance. The opportunities for the continued discharge of such sewage into New York Bay and its being adequately digested would become less and less as years go by and

there is no assurance that, in 1940, to the best of my belief, Newark Bay could adequately care for the treated sewage of the Pas-
3796 saic Valley District. I have no data on current velocities in Newark Bay, but I am of the opinion that they are much lower than those to be encountered in New York Bay, hence I conceive of the probability that some of the suspended particles remaining in the treated sewage depositing on the bottom of Newark Bay, and in a measure producing and maintaining conditions similar to those now existing near the shore line in New York Bay and the East River. It is certainly clear to me that if the effluent of the Passaic Valley Trunk sewer, after treatment, may be discharged without offense into Newark Bay, the possibilities of its creating offensive discharge into New York Bay as proposed are very much less.

Q. What factors would occasion the less offense in New York Bay that did not already exist in Newark Bay?

Mr. Riker: The question is objectionable and is objected to because it does not appear by any testimony that it is a question of less offense, or any offense, in either body of water. The question therefore is not directed to any matter which the witness has testified to.

The Commissioner: Note the objection of counsel for the defendants.

A. The dilution powers of New York Bay waters are clearly much greater than the dilution powers of the waters of Newark Bay.

Q. On what do you base that statement?

A. Some years ago I made a study of the total discharge of the Passaic and Hackensack Rivers into Newark Bay; as a result of this investigation I estimated that the average discharge throughout an average year of the Passaic and Hackensack Rivers into Newark Bay was 1810 cubic feet per second; during dry years this figure was reduced to 1050 cubic feet per second; during the six dryest months in an average year the discharge was estimated at about 900 cubic feet per second, and during the dryest month at 210 cubic
3797 feet per second. Therefore, using the well recognized standard for the dilution of sewage at three feet per second per thousand population the diluting powers of Newark Bay contributed by the fresh water discharge of the Passaic and Hackensack Rivers ranges from a population of 603,000 down to 70,000. It is clear from these statistics that there at the present time exists considerable uncertainty as to whether under the most favorable conditions the fresh waters of the Hackensack and Passaic Rivers would afford adequate dilution of the sewage to preclude the establishment of offensive conditions even during average years; during dry weather periods it would be out of the question.

Q. What do you estimate the tidal prism of Newark Bay to be?

A. I have no knowledge at hand on that.

Q. Does it equal or exceed that flow of the rivers that you have just computed?

A. That I do not know, but as I have stated, it is just as well to make it clear that the fresh water discharge during the six dryest months is not sufficient to care adequately for more than 1/10 of the

population contributory to the Passaic trunk sewer. Therefore any outside assistance from salt water would have to make up this 9/10 deficiency.

Q. In computing the diluting capacity of New York's Upper Bay do you not take into consideration the volume of the tidal prism?

A. I do.

Q. Why don't you equally apply it to Newark Bay?

A. Because I have never paid particular attention to the discharge of sewage into Newark Bay, for the reasons above set forth, namely, that I have restricted myself to the stipulation.

Q. What is the volume of the tidal prism in New York
3798 Upper Bay?

A. In round numbers the volume of water in New York Bay at mean low tide amounts to about 15,400,000,000 cubic feet in the Hudson River, between the Battery and 12th Street 2,490,000,000 cubic feet; in the East River between the Battery and 12th Street, 1,140,000,000 cubic feet, or a total of 19,030,000,000 cubic feet.

Q. What have you stated now in regard to the volume of water in these three areas you have mentioned?

A. The holding capacity of the harbor and of the river between the limits mentioned, at mean low tide.

Q. Does the tidal prism slide backward and forward on top of the mean low water?

A. The tidal prism is approximately 2,500,000,000 cubic feet.

Q. What percentage of the tidal prism represents water that has already been in the harbor, that has gone out on the ebb heavily polluted and returned on the flood filled with this pollution?

A. I have made some computations bearing on this point. In round numbers of the water passing out of New York Harbor on the ebb tide about 51% consists of land water which has entered the bay from the rivers which are contributary to it or been left in the harbor from preceeding tides, and 49% *per cent* is sea water. Of the water coming into the harbor on the flood tide 38% is sea water according to my computations, and 62% is land water which has been carried out of the harbor and into the Lower Bay on preceeding tides. Therefore this data may be summarized as follows:

	Millions of cubic feet.	
	Ebb tide.	Flood tide.
Sea water	6,020	6,850
Land water	6,290	4,180
Total flow	12,310	11,030

3799 I have assumed that the proportion of sea water lost at sea will be proportionately the same as land water not coming back on this basis I have made the following computations with reference to the proportion of new sea water entering with the tide. Land water 4,180,000,000 cubic feet; old sea water; 4,000,000,000 cubic feet; new sea water 6,850,000,000 cubic feet,

minus 4,000,000,000 cubic feet equals 285,000,000, cubic feet. The per cent of new sea water in this case is about 26 per cent.

Q. Where did you get the data on which you have just made these computations Mr. Johnson?

A. From the records of the U. S. Coast Survey and the published reports of the Metropolitan Sewerage Commission.

Q. What was the date of the report of the U. S. Coast and Geodetic Survey from which the figures were taken on which you made your computation?

A. The data from which these computations *where* made were taken from the reports of the United States Coast and Geodetic Survey which appeared in the 1910 report of the Metropolitan Sewerage Commission page 528 and from the report of Col. Black and Professor Phelps submitted to the Board of Estimates and Apporti-ments March 23d, 1911, Complainants' Exhibit 136, page 20.

Q. Then how much do you estimate the return land and sea water on each flood to have been of water that already had been in the harbor and been polluted before it went out on the ebb?

A. In the case of the ebb tide I have taken, 1,182,000,000 cubic feet as the amount of new land water and on the flood tide 285,000,000 cubic feet of new sea water.

Q. Can you reduce that to percentages; what per centage of the flood represents water that already has been in the harbor whether fresh or salt and which went out on the ebb after being polluted?

3800 A. I figure as before stated that the new sea water which has never before been in the Harbor amounts to about 26%.

Q. Have you read the testimony of General Roberts given for the defendant in this present suit?

A. No sir.

Q. Do you know who General Roberts was or is?

A. I have known but I could not say now.

Q. How do you define the terms you have used "dilution" "diffusion" and "dispersion" relative to their sewage effluent that is to be discharged into New York Upper Bay?

A. I shall have to reverse the order in which you have given these terms and start at "dispersion."

By dispersion I mean the discharge of one liquid into and through another.

By diffusion I mean a more or less mixing of the two liquids.

By dilution I mean the proportion of the diluting liquid to the liquid added to it.

Q. Does the condition of the diluting liquid influence your opinion relative to the effect of dilution upon sewage effluents discharged into the diluent?

A. It affects it in so far as the relative specific gravities of the two liquids are concerned.

Q. How respecting the assimilative properties of water into which sewage is discharged?

A. I suppose, in precise terms, that it should be stated that theoretically that salt water possesses 4/5 the assimilative power of fresh water for sewage digestion. Up to the point where dissolved oxygen is contained within the body of water sewage, I believe no nuisance will be created; the nuisance then will be restricted to the deposits undergoing putrifaction on the bottom of the bay.

Q. If the dilutent water is already polluted to the fullest exte-*d* of its power of assimilation will that influence your opinion
3801 in estimating its diluting power for a sewage effluent about to be discharged into it?

A. The plain facts are in this instance the diluting powers of New York Bay waters have not been reached, any where near. The fact that unsatisfactory, unsanitary objectionable conditions, obnoxious conditions, exist around the shore lines is due to the present improper method of disposal of the sewage of New York City, and perhaps in a far less degree to similar methods adopted by cities in New Jersey located on New York Harbor waters.

Q. How do you distinguish the degree between New York City and the New Jersey riparian cities on New York Upper Bay?

A. It has already appeared in the testimony that the amount of sewage discharged by metropolitan New York was 604,000,000 gallons per day in 1905.

Q. Was that volume of Sewage discharged from Metropolitan New York into Upper New York?

A. The statement in 1910 report of the Metropolitan Sewerage Commission, page 76 is that this sewage produced in the Metropolitan District was discharged into the harbor either directly into or near open navigable channels, or indirectly into those channels by way of rivers.

Q. Do you regard New York Lower Bay as part of the Harbor of New York?

A. I do not know whether it is so considered or not, but the one thing that I was coming to in this discussion was that the population of Metropolitan New York outside of New York proper in 1905 represented only about 20% of the combined population of New York City and districts lying outside the city limites but within the 25 mile metropolitan limit.

(Recess was then taken.)

3802 Q. What percentage of the sewage of Greater New York is discharged other than into New York Upper Bay?

A. The only territory in New York discharging other than into Upper New York Bay is that area tributary naturally to Jamaica Bay and waters lying south thereof.

Q. Does any part of the sewage of greater New York discharge into the Atlantic Ocean itself?

A. I have no knowledge of *their* being any outfalls of size discharging directly into the ocean from New York City.

Q. Does any portion of the sewage of greater New York discharge in to New York Lower Bay?

A. Indirectly I think that all of the sewage of New York City with the exception of that part naturally tributary to Jamaica Bay does find its way into Lower New York Bay.

Q. Is there any direct discharge into Lower New York Bay that you know of from the Greater City of New York?

A. I know of none of any practical significance.

Q. The tidal prism that you have testified to and which you have made computations for, did that relate to average conditions from tidal prism or to any special seasonal tidal prism?

A. I have not the detailed figures before me but am of the impression that the figures given represent the average conditions.

Q. Do tidal prisms in New York Upper Bay vary with the seasons and do they also vary with the phases of the moon?

A. They do.

Q. Within what limits?

A. I cannot state in precise terms what those would amount to although I have studied the question somewhat.

Q. Is the variation a very great or a very small one?

A. That I am unable to say in as much as my investigations only related to studies directed at the location of the highest
3803 point north in the Hudson River into which sea water would be carried; the highest point north was fixed during the change of the moon following a prolonged drought and at a time when heavy winds were blowing from the south.

Q. Have you ever known a condition in New York's Upper Bay where there was no tidal prism for more than one tidal cycle?

A. Where ever there is a rise and fall in the tide it is possible to figure a tidal prism according to my understanding. I know of no such point as you mention.

Q. How far up the Hudson River did you find salt water and does the tidal action reach?

A. Tidal variations are noted as far north as the Troy dam the normal chlorine contents of the waters of the Hudson river were found on the 30th of May, 1903, by me, to terminate 10 miles south of Poughkeepsie at approximately 65 miles from New York.

Q. Have you ever heard of a period in New York's Upper Bay when there was no actual tidal prism for several tidal cycles?

A. I have not.

Q. Do you believe such a condition is liable to obtain or has ever obtained?

A. If you are referring to the entire Bay, I think it is highly improbable that it would ever obtain.

Q. Have you ever made any investigations to determine whether or not the absence of a tidal prism in New York Bay has been recorded within 2 or 3 years?

A. No sir.

Q. You will find, if you do make such investigations, Mr. Johnson, that in December, 1911, for three tidal cycles no tidal prism obtained in New York's Upper Bay?

Mr. Riker: The statement of counsel is objected to, and in the

form of a question, should not go upon the record, as coun-
3804 sel is not testifying.

The Commissioner: Note the objection of counsel for the defendants.

Q. You stated in reply to a question, Mr. Johnson, that you thought that Newark Bay could receive the effluent from the sewage works as are described in Complainants' Exhibit No. 135, and could assimilate or accommodate such effluent with out nuisance or offense for several years, although you did not think it could accommodate that effluent with out offense for as long as the year 1940. Is that right?

Mr. Riker: The question is objected to in the form it is put because it is not in accordance with the testimony given by the witness; the testimony of the witness was carefully guarded and was not in the form nor of the breadth that counsel has assumed in his question.

The Commissioner: Note the objection of counsel for the defendants.

Mr. Riker: A further objection is that if he had so testified the record would show it and he should not be called upon to re-state his evidence.

The Commissioner: Note the further objection of counsel for the the defendants.

A. In a very general way it is, but I qualified that statement by calling attention to the probably low velocity of the flow in Newark Bay as being likely to permit at times of the deposition of such solid matters or of portions of them as might escape the treatment works. Furthermore I call specific attention to the diluting powers of the fresh waters of the Passaic and Hackensack Rivers as being entirely inadequate at times of dry years.

Q. For how many years in your opinion could Newark Bay receive the effluent described as capable of being produced by the plant as set forth in Complainants' Exhibit No. 125?

Q. In the first place it is necessary to assume that such
3805 deposits as have been forming for years on the beds of the rivers discharging into Newark Bay and on the bottom of the Bay itself will be removed or at least that putrifactive agencies will have ceased. So for as estimating the period of years during which Newark Bay could receive the effluent of the treatment works and digest it without nuisance, not knowing the statistics with reference to the tidal prism, I am unable to answer.

necessary in the case of Ne wYork. As one further reason why the

Q. Can you approximate the number of years, Mr. Johnson?

A. Without the tidal prism, I could not, no sir.

Q. In what particular are the sewage disposal works described in complainants' exhibit No. 135 superior to the sewage disposal works of Columbus at the time of your connection with those sewage disposal works in Columbus, Ohio.

Mr. Riker: The question is objected to in as much as it is irrele-

vent and immaterial what the relative values of the two works are unless it be shown that they are to operate under the same conditions and discharge into the same diluting element.

The Commissioner: Note the objection of counsel for the defendants.

A. In answering your question it is necessary to make clear that Columbus is situated on an inland stream and that the effluent of the sewage works is disposed into that stream some 200 miles by water below the point of discharge in the intake of the Cincinnati Water Works. It was therefore deemed advisable to purify the sewage of Columbus somewhat more thoroughly than is considered necessary in the case of New York. As one further reason why the complete work of Columbus were adopted is the fact that it was considered advisable in order to guard against possible litigation on the part of riparian owners below Columbus, to take out of the sewage as much as possible of the suspended matter and to discharge into the river at all times an effluent which would contain dissolved oxy-
gen, which would not putrify and which would not draw on
3806 the dissolved oxygen contents of the river waters to make up
any deficiency that might obtain. In New York Harbor conditions are entirely different; the waters are not used for drinking purposes, the shellfish and the fish industry in general has been abandoned; no matter how carefully the sewage is purified that may in the future be discharged into New York waters the fish, and the shell fish industry in particular would have to be abandoned,—could not be considered as safe. Therefore the only think necessary in this proposition is in line with the requirements of the stipulation namely, to remove from the sewage such suspended matters of a sufficiently large proportion of readily oxidized organic matters which might cause an abnormal withdrawal of oxygen of waters of the harbor. In effect all that is required, in my opinion, in the case of the disposal problems in New York waters, particularly in Upper New York Bay is the disposal of sewage in a way which will not establish or maintain æsthetically objectionable conditions. It is not a problem relating to the public health except in so far as the isolated proposition of Jamaica Bay is concerned. There, if it is desired to protect the shell fish, industry, a further treatment with such works as are proposed for the treatment of the Passaic Valley Sewage with hypo-cholorite of lime, will affect the desired end.

Q. From your studies of the plans and specifications of the Passaic Valley Sewerage Commissioners, and particularly as set forth in Complainants' exhibit number 135, in your opinion is the plant to procure the effluent stipulated for in that exhibit as efficient as the plant that was operated in Columbus, Ohio, during your connection with that sewage disposal plant?

Mr. Riker: The question is objected to upon the ground that this witness has already stated that he has not examined the plans and specifications of the Passaic Valley Sewerage Commissioners, but has examined only the stipulation.

It is further objected to on the ground that there is no
3807 effluent described in the stipulation in question but that certain results are guaranteed to be produced by subjecting the sewage to such treatment and that therefore the assumptions of the question are not proved as facts in the case and the question is therefore objectionable.

The Commissioner: Note the objection of counsel for the defendants.

A. It is not. The reasons for it have previously been made clear. The thoroughness with which sewage shall be purified is always governed by local conditions.

Q. The results of the work done at Columbus, Ohio, and which were published in the report from which you have read, the report of sewage purification at Columbus, Ohio, dated November 10th, 1905, was that work reported and tabulated in various parts of that report done at a regular sewage disposal plant or done at a testing plant during your con-ection with the Columbus, Ohio, purification, plant?

A. All of that work was done in the testing station to enable the authorities to decide as to the method which proved, under test, to be the most economical and efficient. The recommendations contained in that report which were based upon results obtained in the testing station were followed in the design of the main sewage disposal works which are now in operation.

Q. After screening and sedimenting the sewage for one and a half hours in the Columbus, Ohio, plant, what was the highest percentage of the removal of suspended matter that you were able to obtain?

A. We made no continuous record of the amount of suspended matters removed by screen; the screened sewage sedimented for a period of one and a half hours showed a total removal of suspended matters of 34% on the average.

Q. After screening the Passaic Valley sewage and sedimenting for a period not less that one and a half hours, as set forth in the stipulation, why do you express the opinion that you can
3808 secure the removal of 50% of the total suspended matters?

A. The statement which you have referred to was intended to represent a probable removal of suspended matters by screening and sedimentation and not by sedimentation alone; by sedimentation alone I have assumed the removal of 35%, by screening 15%, a total of 50%.

Q. In operating the Columbus, Ohio plant after screening and sedimenting, the sedimentation period being one and a half hours, how much did you remove of the total suspended matters?

A. During the passage of the sewage through the sedimentation tank, termed "grit chamber", the period of sedimentation was one and a half hours and the removal of suspended matter amounted as before stated to 34%.

Q. Was that sewage, before entering the sedimentation chamber, screened?

A. It was.

Q. Did it pass through three sets of screens?

A. It did.

Q. There was a third set of screens finer than anything stipulated for in complainants' exhibit number 135?

A. The first screen had a clear opening of 5/10 of an inch the second screen had a clear opening of 5/10 of an inch, and the third and final screen had a clear opening of .375 inch, which was very slightly smaller than the opening provided for in the stipulated screens for the Passaic Valley District, which provides a clear opening of 4/10 of an inch.

Q. Is there any where recorded in this Columbus report the fact that you were able to remove 15% by the screening operations at Columbus, Ohio during your connection with the plant?

A. I think not.

Q. Can you refer me to any published report or work on sewage disposal which states that such screen as you have described will remove 15% of the total suspended matter.

3809 A. I have referred previously in my testimony to the results recorded by Professor Doctor Dunbar in which, if my recollection serves me correctly, the statement is made that 28% of the total suspended matter is removed by screens.

Q. Will you please give me the page, Mr. Johnson, in which Dr. Dunbar reports that?

A. Page 257 of "Principles of Sewage Treatment" by Doctor Professor Dunbar and H. T. Calvert. It is necessary to state that the precise removal of suspended matter in terms of percentage removal is not stated by Doctor Dunbar and has been computed by me as follows:

He states—(Interrupted.)

Q. On what page?

A. At page 258—that one pound of material is removed for every 22 to 45 persons, according to the size of the apertures of the screens; on this basis the ratio of a pound of material removed for every 22 to 45 persons are equivalent to 20 to 40 grams per capita daily. For screens of the Hamburg type which provide a clear opening of 4/10 of an inch, the lower ratio of 20 grams per capita per day has been taken; on the basis of 75 grams per capita per day of suspended matter contributed to sewage, this is equivalent to 26.7 per cent removal.

Q. And that computation you make yourself, do you not, Mr. Johnson?

A. I do.

Q. Is the author of the work that you have just quoted from now, Doctor Dunbar, and engineer?

A. I do not think he could be considered an engineer; he is generally in the possession of the necessary engineering facts which are acquired in the study of sewage disposal problems.

Q. Is Doctor Dunbar an American or a German?

A. It is my impression that he was born in America, but for the past 20 or more years has resided in Germany.

3810 Q. What size mesh did he use in the data which you have quoted from him and which you take as to basis of your computation?

A. The largest size screen to which he referred I have assumed was the Hamburg screen because that is the one which he has studied with the greatest care.

Q. Have you any definite knowledge as to the sized screens that he used?

A. In his discussion he refers to a variety of screens having clear apertures ranging from very large to very small, the smallest probably being that at Dresden.

Q. With what mesh?

A. The Dresden screen is a perforated cloth, the apertures have clear openings of 1/12 of an inch.

Q. How would that compare with the Passaic Valley mesh, or the mesh of the screen outlined in Complainants' exhibit number 135?

A. It is several times finer; but that screen I did not take into consideration in my computations.

Q. Why do you select the coarsest screens mentioned by Dr. Dunbar, rather than the finer screens mentioned by Dr. Dunbar, as the basis of your computations?

A. In order to be on the entirely fair side and because of the fact that the Hamburg screen is almost precisely, if not exactly, the same size with reference to open space as that called for in the stipulation.

Q. Is Dr. Dunbar's work confined to the operations of a plant or to experimental work, preliminary to the designing and operating a plant?

A. Dr. Dunbar for many years has been the active head of investigations into methods of sewage disposal and as such has made it a life study to keep closely in touch with developments in all branches of the art.

Q. And the data which you used of Dr. Dunbar's, was that data from experimental works in a testing station or through the
3811 operation of plants?

A. I think I am correct in assuming that the data which I have referred to were obtained by Dr. Dunbar in the course of investigations of actual sewage disposal plants in operation.

Q. Was the Dresden plant in operation at the time that book of Dr. Dunbar's was published?

A. I think it was, in part; but I can go even further in connection with the Dresden screen, by saying that Dr. Dunbar, (page 59 of his book) indicated that the removal by the Dresden screen is 43% of the suspended matter in the sewage. Recent inquiry on my part has brought out the fact that these screens actually removed a larger per centage of the suspended matter than that indicated by Dr. Dunbar.

Q. Does Dr. Dunbar, any where in the books you have quoted from, sate that he gathered his data from the Dresden plant or that he conducted any of his experiments in the Dresden plant?

A. It is to be presumed that his results were obtained during the

operation of experimental installation at Dresden prior to the publication of his book in 1908.

Q. Are you quite positive about that?

A. I am not.

Q. Are you positive as to whether the screen that he operated with was a perforated cloth or a perforated plate?

A. It is difficult to distinguish between a perforated metal plate or a perforated metal cloth unless the cloth be woven; it is true, in this case, that the Dresden screen is composed of a sheet of metal, perforated with rectangular slots with a clear opening, as before stated 1/12 of an inch.

Q. Will you describe the construction of these plates or screens, how many of them there are and how they are arranged?

A. I could not tell you that. I know that as a general rule the screens are about 15 feet in diameter and built circular in plan so as to take the entire flow of the sewer. It is not improbable
3812 that they may be made of different diameters to fit the particular sewer in which they are installed.

Q. Are you quite sure that the data which you read from Dr. Dunbar's work and which you took as your basis of computation was not experimental work conducted by him with the view of determining just what character of screen would be most efficient for the Dresden plant?

A. I do not, but I know that these screens have been adopted by Dresden and that they are in operation.

Q. How would the Dresden sewage compare with the Passaic Valley Sewage?

A. I presume it would be in round numbers from two to three times as strong.

Q. And as to freshness?

A. I do not know.

Q. Do you know whether Dr. Dunbar conducted these experiments himself or not?

A. The book is by himself and Mr. Calvert, therefore I presume that the tests were made either by himself or Mr. Calvert or both.

Q. Have you any definite knowledge as to who conducted the experiments that are recorded and which you took as the basis of your computations and as to whether or not there were check experiments made on these which in any way modified them?

A. I have no knowledge of that, but I have kept closely in touch with this phase of sewage disposal matters for a number of years, and I know this view as to the efficiency of the screens at Hamburg that I have expressed is also held by numerous other workers in this field. Mr. Hering, I am certain, is very firmly of the opinion that the Hamburg screen is as efficient as I have stated, if not more so, in fact he favors that screen to the best of my knowledge, in preference to others.

Q. How does the Hamburg screen compare with the Dresden screen?

3813 A. The Dresden screen has very much finer openings.

Q. Have you examined the screen at the Dresden Sewage Disposal Works yourself, personally?

A. I have not beyond the photograph of those screens, which I believe to be authentic.

Q. Is it not a fact that both the Hamburg and the Dresden sewage are fresher and stronger than the Passaic Valley Sewage would be as conducted in this trunk sewer to the disposal works and through the tunnel outward to the outfall in New York Upper Bay?

A. It certainly is stronger owing to the lower water consumption in Germany, but as to its putrescibility I am unable to give you any opinion.

Q. What year did you first become attached to the Columbus, Ohio, sewage disposal works?

A. 1904.

Q. What age were you then?

A. Thirty.

Redirect examination by Mr. Riker:

Q. Have you had access to a series of printed reports of the Metropolitan Sewerage Commission, entitled "Preliminary Report" and issued recently?

A. I have.

Q. Have you examined them?

A. I have.

Q. Do you find in them any proposal for treating the sewage of certain territory within the Metropolitan Sewerage District by means of purification plants?

Dr. O'Sullivan: Objected to as introducing new matter and, not redirect.

The Commissioner: Note the objection of counsel for the complainants.

Dr. O'Sullivan: And also on the ground that it is not relevant to the issues.

3814

The Commissioner: Note the further objection of counsel for the complainants.

A. I have.

Q. Are any of the proposed purification plants recommended by that Commission as efficient as that which is described in the stipulations, Complainants' Exhibit Number 135?

A. The recommendations of the Metropolitan Sewerage Commission with respect to the purification of the sewage of New York city and Metropolitan New York, contemplate the use of what are clearly methods and devices almost precisely the same as those called for in the stipulation in connection with the Passaic Valley project.

Q. Where is the sewage treated in this way to be discharged in a general way, into what waters?

A. I find a reference in the preliminary report number 5 of the Metropolitan Sewerage Commission bearing date September, 1912, page 5, where the following statement is made:

"Moreover it seems certain that the Kill von Kull with its deep water and swift current would provide for many years, if not for all times, a sufficiently favorable place for discharging the sewage from

the areas bordering on Newark Bay and the Kill von Kull, after it has passed through settling tanks."

Q. In your judgment is the Kill von Kull as safe a place for the discharge of that sewage so treated as the waters at Robbins Reef in New York Bay?

A. I do not think so because of the far less favorable opportunities afforded for adequate dispersion and digestion.

Q. Have you seen copy of the stipulation by the State of New York and the Bronx Valley Sewerage Commissioners with the United States Government?

A. I have.

Q. Do you recall that that provides for the removal of 10% of the putrescible matter from the sewage to be treated in the purifi-
3815 cation works?

A. It does.

Q. In your judgment is that as high a degree of purification as will be the result of the treatment described in the stipulation between the United States, the State of New Jersey and the Passaic Valley Sewerage Commissioners?

A. It is not.

Q. Do you know where that Bronx Valley Sewer discharges?

A. The Bronx Valley sewer plans provide for a trunk line some 14 miles long, extending from the northern limits of White Plains to within 300 feet of the boundary between the Borough of Bronx and Westchester County; the trunk sewer turns then west, parallel to the boundary line, and discharges through a tunnel into the Hudson River; it terminates therein in two lines of 54 inch cast iron pipes.

Q. Is that point of discharge somewhere in the neighborhood of Yonkers?

A. Yes, sir.

Q. What is the material of which the Bronx Valley Sewer is constructed?

A. It is a concrete sewer built of cement, sand and crushed stones, and the size of this trunk sewer ranges from three feet 4 inches at its upper end, to 6 feet 6 inches at Washingtonville, the point of deflection to the Hudson River, where it increases to eight feet.

Q. In reaching the conclusion to which you have testified as to the result of the discharge of the Passaic Valley Sewage treated as provided in the stipulation, I think you have testified that you estimate that 10% of the total flow of the sewer would be trade wastes. Now, Mr. Johnson, assuming that the trade wastes discharged from this sewer are reduced to 10% of the total, trade wastes would that result in a less or greater degree of purity in the sewage treated and discharged at Robbins Reef, from what you have estimated as the amount of trade wastes?

3816 A. I should express the opinion that it would result in a sewage of better character as delivered at the treatment works.

Q. You were asked with reference to the discharge of sewage treated as prescribed in the stipulation, Complainants' Exhibit Number 135 and pointed out the effects of fresh water flow; have you taken into consideration at all in your answers which you have given on

cross examination, the fact that there are other polluting sources of the waters of Newark Bay besides the Passaic Valley?

A. In my assumption I have assumed that all sewage now entering the Newark Bay would be withdrawn and that only *the* treated of the Passaic Valley District would be discharged into it.

Q. Do you know whether or not the city of Elizabeth discharges sewage into Newark Bay?

A. That is my impression.

Q. Do you know whether there are discharges of sewage from Jersey City into the Hackensack River and Newark Bay?

A. Yes, sir, there are.

Q. Do you know whether or not there are other sources of pollution further up the Hackensack?

A. There are, a number.

Q. Then would or would not the removal of the Passaic Valley pollution from the Bay entirely remove the polluting matters from the Bay?

A. It would not.

Q. You have been asked with reference to a report by Messrs. Hazen and Whipple, upon the trade wastes and sewage problem of the City of Paterson; with what view, if you know, was that report prepared for the City of Paterson?

Dr. O'Sullivan: The question is objected to on the ground that the intention behind the report is not relevant to this inquiry.

The Commissioner: Note the objection of counsel for the complainant.

3817 A. It is my belief that this investigation conducted by Messrs. Hazen and Whipple which resulted in the report you have mentioned was made with the view of determining the feasibility and cost of constructing and operating independent sewage disposal works for the City of Paterson.

Q. Do you know where they were to be located?

A. It is my impression that they were to be located below the Dundee Dam.

Q. On what river?

A. On the Passaic River.

Q. Were they too as you understand it, to take care of the trade wastes of the city of Paterson?

A. They were.

Q. And to discharge a treated sewage into the Passaic River which would not pollute the waters of the river?

A. In general terms that is so. I presume what they would aim to accomplish would be the purification of this sewage to a point where it would not render the Passaic River more polluted than it was before it received the purified effluent.

Q. In your opinion would an effluent from the city of Paterson, subjected to the same purification treatment, be as safely discharged just below the Dundee Dam in the Passaic River as at Robbins Reef in New York Bay?

Dr. O'Sullivan: The question is objected to as not being redirect and not being relevant to any issue in this case.

The Commissioner: Note the objection of counsel for the complainant.

A. If the treatment works for the purification of Paterson sewage were of the type called for in the stipulation (Complainants' Exhibit No. 135) for the entire Passaic Valley District, it is my opinion that the effluent of these works could not be discharged safely into the Passaic River below the Dundee Dam without creating a nuisance.

3818 Q. If it be a fact that there are tidal periods in which there is no tidal prism in New York Bay, what effect would that fact have upon the conditions created by the City of New York through its method of discharging its sewage into New York Bay as to rendering it more or less injurious than it is under normal tidal conditions?

A. Under such conditions as those the existing unsatisfactory condition near the shore line would be materially increased in intensity.

Q. Returning with one further question to Newark Bay as a body of water into which treated sewage may be discharged, as to relative depth and the difference in New York Bay would the conditions in New York Bay at Robbins Reef have any influence on the question as to which is the better disposal ground?

A. The depth at which the sewage is discharged has a great deal to do with the efficiency of the dispersion of the sewage; the deeper the better the results are bound to be.

Q. Have you any knowledge of the depth of the channel in Newark Bay?

A. I have not except in a general way; I have passed through Newark Bay in a tug boat and at that time the waters were sufficiently shallow throughout practically the entire length of the Bay to allow the propeller to draw up to the surface volumes of black sludge.

Q. I draw your attention to Complainants' Exhibit No. 135, and particularly to this statement in the stipulation; "After passing through such coarse screens the sewage shall pass through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage or other matters shall pass through self cleansing mechanical screens, having clear openings of not less than 4/10 of an i-ch." Do you or do you not understand that that is a limit and not a requirement as to exact size?

A. That is precisely the case.

3819 Q. If that mesh should not prove efficient, do you or do you not understand that a mesh of smaller dimensions would be a requisite lawful additional arrangement which the stipulation provides shall be used if necessary to produce the guaranteed results?

A. That is my opinion.

Recross-examination by Dr. O'Sullivan:

Q. Do you understand, Mr. Johnson, that the 4/10 mesh, 4/10 of an inch, to be the maximum or the minimum to be employed by the Passaic Valley Sewerage Commissioners?

A. I understand that to be the maximum size of apperature called for in the stipulation.

Q. What provision in Complainants' Exhibit No. 135 do you find for the use of a finer mesh?

A. I believe that this point is adequately covered in articles 2 and 5 of the stipulation.

Q. In the article second, appearing on page three of the stipulation provision is made, is it not, that either through compliance with the requirements of the immediate preceeding paragraphs, or through requisite lawful additional arrangements there shall be the thing stipulated for, do you so understand it?

A. Yes, sir.

Q. What are the requisite additional lawful arrangements?

A. It is my understanding that the War Department of the Federal Government is the supreme authority in regard to such matters as this; if, in my judgment, the devices installed by the Passaic Valley Trunk Sewer District shall not effect the results called for in article 2 of the stipulation, as I personally believe they will, it is within the authority of the Federal Government to place still further restrictions on the matter in which the desired result shall be obtained.

Q. Do you make any distinction, Mr. Johnson, between
3820 "Requisite additional arrangements" and "Requisite lawful additional arrangements" in your inperpretation of Complainants' Exhibit No. 135?

A. To my mind they are synonomous as applied to the authority of the War Department of the Federal Government.

Q. Conceding that they would be requisite how would you determine whether they were lawful or not, these additional arrangements to sucure the stipulated results?

A. It appears clear to me, as before stated, that the Federal Government is the deciding power.

Q. And that the municipalities and town ships entering into this contract would have no alternative but to obey, is that your inperpretation?

A. The Federal Government exercises jurisdiction over the waters of New York Harbor and I see no reason to believe that they would not be perfectly justified under the law in placing any further restrictions they might see fit to place on the manner of treating the Passaic Valley Sewage.

Q. I will repeat the question. (The last question read.) I ask you if you can give me a more direct answer.

Mr. Riker: The question is objected to as calling for a legal conclusion by this witness as to matters which he does not claim to be an expert on and cannot be.

The Commissioner: Note the objection of counsel for the defendants.

A. Undoubtedly such a decision would be arrived at through cooperation between the Federal Government and the interested municipalities.

Q. I ask you if you can give me a more direct answer to my question and ask that it be read again.

A. That is the most direct answer I can give you.

Q. What is the debt limit of the City of Newark?

Mr. Riker: What is the question.

Dr. O'Sullivan: What is the debt limit of the City of Newark?

3821 Mr. Riker: If you know.

A. I do not know.

Q. What is the debt limit of the City of Paterson?

A. I do not know.

Q. What is the debt limit of the City of Passaic?

A. I do not know.

Q. Can you tell me the debt limit of any of the municipalities or townships who have already entered into contract with the Passaic Valley Sewerage Commissioners?

Mr. Riker: The question is objected to as being immaterial and irrelevant, not relating to any issue in any way, and apparently based upon a misconception that debt limits in the State of New Jersey are constitutional matters not subject to alteration by legislation.

The Commissioner: Note the objection of counsel for the defendants.

A. I cannot.

Q. Can you tell me the extent to which the Governing powers in any one of these cities or municipalities can contract or authorize debt in relation to the Passaic Valley Sewage Problem?

Mr. Riker: The question is objected to as this witness does not profess to be an expert in law.

The Commissioner: Note the objection of counsel for the defendants.

A. I cannot.

Q. Would it be necessary for you to know these facts before you could determine whether a requisite additional arrangement was also a requisite lawful additional arrangement, and before answering questions along that line?

A. It would, but the facts are clear to me, and they appear throughout my entire testimony that the treatment of the Passaic
3822 Valley Sewage according to the stipulation will be sufficient to preclude offensive conditions being established and maintained in New York Bay.

Q. How about Newark Bay in case the same effluent was discharged into Newark Bay?

Mr. Riker: The question is objected to as immaterial.

The Commissioner: Note the objection of counsel for the defendants.

A. I have already answered that question in as great detail as I am able to.

Q. Mr. Johnson, will you compare complainants' exhibit No. 177 with the complainants' exhibit No. 135 and indicate wherein there is superior treatment for the Passaic Valley Sewage to that afforded the Bronx Valley sewage?

A. The stipulation and agreement in the case of the Bronx Valley Sewer is more specific in some particulars than is the stipulation in the case of the Passaic Valley project, and in this connection I refer to article first of complainants' exhibit No. 177 wherein it is set forth that the plan for the partial purification of the effluent of the Bronx Valley Sewer system by screening and sedimentation shall have an efficiency sufficient to remove and it shall at all times remove from such effluent enough of its putrescible contents to purify the same to the extent of ten per cent upon an absolute putrescibility scale. It is my opinion that in the case of the Passaic Valley project this result will not only be reached but exceeded.

In article four of the same exhibit I note that the Federal Authorities shall have full opportunity to inspect the construction of the proposed purification plant and the condition and working of the entire system in order to determine whether the terms of the provisions therein are being observed in all respects, and to this end the Commissioners (presumably the Bronx Valley Sewerage Commissioners) shall render such expert or other assistance as
3823 they may request.

The Secretary of War at all times shall have the right to determine whether such terms and provisions are being complied with and upon notice from him that they are not the Commissioners or their successors shall forth with do whatever may be necessary in order to affect compliance therewith.

This is in line with my interpretation of the Passaic Valley stipulation.

Q. Do you know who drew those stipulations, the engineers who were in charge of the stipulations, and whether they were the same engineers or not?

A. I should be inclined to the belief that they probably were consulted.

Q. Look at the results guaranteed in the two exhibits, complain-ts' exhibit No. 177 and complainants' exhibit No. 135 and see which is the most stringent in its terms?

A. I will express the opinion that the stipulation in the case of the Passaic Valley Trunk Sewer is the more stringent.

Q. Based upon what fact or facts?

A. It is specifically stated in the stipulations governing the Bronx Valley project, complainants' exhibit No. 177, that in connection with the absence of deposit in the waters of the Hudson River from the effluent of the said sewer, and with regard to the

absence in the waters of the Hudson River and its vicinity of any odor due to the putrefaction of organic matter, the final decision with regard to these features rests with the Secretary of War, and exercising a reasonable discretion; I believe perhaps that is a feature of some *some* minor importance but it is not so stipulated in the Passaic Valley stipulation, although it is to be inferred.

Q. From what would you infer that in the case of the Passaic Valley Sewage effluent?

3824 A. I would infer it from what I have already said, that the Federal Government is a supreme authority a court of last resort.

Q. And even though it be not expressed in terms you would concede that they have the power and the right, is that it?

A. Yes sir I would.

Q. How does the sewage to be transported in the Passaic Valley trunk sewer compare to the sewage to be transported by the Bronx Valley Trunk Sewer as to the character of the sewage?

A. There are many common features in connection with the two projects. Namely, the Bronx sewer is 14 miles long from its upper end to the boundary line between the Borough of Bronx and Westchester County; the total length of the Bronx Valley Sewer is not materially shorter than is the Passaic Valley Sewer, although perhaps that is a little too strong. The total length of the Passaic Valley Sewer from its uppermost end to the point of discharge in New York Bay being some 26 miles. The Bronx Valley Sewer being approximately 17 or 18 miles. The sewage is discharged into the Hudson River near the boundary line, and just north of the limits of New York City, through a tunnel and at the river bank it terminates in two lines of cast iron pipe, and extends about 500 feet from the shore and discharges in 40 feet of water; which is precisely what is proposed in the Passaic Valley project.

I see very little difference in the two with the exception that the sewage is pumped in the case of the Passaic Valley project.

Q. I asked particularly relative to the character of the sewage to be transported by each of these sewers, how would they compare?

A. That I could not state in precise terms. I understand that in 1910 the population of the district tributary to the Bronx Valley sewer was in round numbers thirty five thousand and that the ultimate population to be provided for by this sewer is 680,-

3825 000 people.

Q. In what year?

A. I do not know that, that is the ultimate capacity of the sewer.

Q. As to the character of the sewage itself, Mr. Johnson, whether it is residential, or trade wastes, or factory wastes, or all three, how do they compare, the Bronx Valley Sewage with the Passaic Valley Sewage?

A. The area drained contains such places as White Plains, Scarsdale, Yonkers, Tuckahoe, Bronx Valley, and Mount Vernon; there are numerous industries in the district and it is probable that the percentage of trade wastes will be reasonably large as compared with the total flow of the sewage from the present district.

Q. Have you made an effort to compute the amount, or the relative proportion of trade wastes to be accommodated by the Bronx Valley Sewer?

A. I have not.

Q. Do you know who the consulting engineer in charge of the enterprise was?

A. I know there are several, I do not recall now the one to whom you probably refer.

Q. Do you know whether Mr. Nicholas S. Hill was or was not?

A. He had a great deal to do with it.

Q. Did you read his testimony as given in this case?

A. I do not recall that I did.

Q. Do you recall whether or not he stated that the trade wastes were practically negligible and that the entire sewage flow was from residential districts?

A. Not having read his testimony I am unable to answer.

Q. Do you know as a matter of fact whether the trade wastes are insignificant or not to be accommodated by the Bronx Val-
3826 ley Trunk Sewer?

A. I do not.

Q. Can you name any industries in the Bronx Valley Trunk Sewer district which would be likely to contribute trade wastes or factory wastes?

A. I have never paid any particular attention to the industrial life of these communities.

Q. These communities contributing to the Bronx Valley Trunk Sewer, do you know whether or not they are sewered on the combined sewer system or on the separate sewer system?

A. I do not.

Q. Do you know what the size of the Bronx Valley Sewer is as to its calibre and as to the amount of sewage that it is capable at maximum of transporting?

A. The concrete main trunk sewer is 6 feet 6 inches in diameter at its upper end, and increases to 8 feet at the Hudson River.

Q. How does the Passaic Valley Trunk Sewer compare in its length and size or calibre with the sewer which you have just described for the Bronx Valley.

A. Its calibre is about 60 per cent greater to the best of my knowledge, and it is several miles longer.

Q. As to the volume of sewage to be transported by each, how do they compare?

A. The Passaic Valley Trunk Sewer is designed on the basis of caring for a population of 1,600,000 people; the Bronx Valley sewer is designed on a basis of caring for a population of 680,000 people.

Q. Is the sewage collected from the combined system harder to be treated than the sewage collected by separate systems?

A. There are many things to be said in that respect; volume for volume the combined is easier to treat. But there is one feature which has a great deal of significance and in my opinion plays no small part in the offensive condition which now exists
3827 around the shores of New York, and that is this, that a conservative estimate of the total number of horses in New

York is one hundred and fifty to two hundred thousand; the excrements of a single horse is equivalent to that of ten men therefore we have street wash going into the harbor now in New York alone containing the excrements of horses equivalent to the discharge of wastes of a million and a half to two million people. That matter is always found in combined sewage systems; that it is readily deposited at high velocities of flow is demonstrated by the results obtained at Columbus, to which I have already referred; its effect on the putrescibility of the deposits gathering on the floors of these tanks has been amply shown; it is doubtless in all cases highly polluting.

Q. What is the average age of the sewage of New York City, Mr. Johnson?

A. For the most part the sewage of the Borough of Manhattan is discharged into the New York waters as fresh owing to the short sewer line.

Q. Why is combined sewage easier to treat than separate sewage, sewage collected by separate systems, Mr. Johnson?

A. Because it contains, volume for volume, less organic matter if we exclude consideration of the excrements from horses.

Q. How would you identify the odors or injuries that might come from the Passaic Valley Sewage being discharged into New York Upper Bay from injuries from other sewages which find their way there?

A. I think the best way to settle that fact would be the demonstration of the fact that the discharge of the Passaic Valley Sewage into the Bay at Robbins Reef Light did not make conditions in the Bay worse.

Q. How would you determine whether they were worse or not?

A. New York sewage has so badly fouled the harbor at
3828 the present time that it would be mighty hard to draw the line of distinction.

Q. In that fouling condition have the riparian cities of New Jersey contributed in a large or small measure?

A. I think that the most conservative statement that could be made, and the most liberal statement in that regard, would be that the other communities than New York, the sewage of whom ultimately reaches New York Bay, represents not more than 15% of the total.

Q. Does that generally measure the amount of pollution of a community the actual number of people in that community?

A. It does.

Q. Do particular forms of trade waste exag-erate the numbers to the extent of greater pollution, from smaller communities, than from larger communities in purely residential districts contributing domestic sewage.

A. So far as the digestive properties of the water are concerned that is true.

Q. What is the shallowness that you alluded to a moment ago in Newark Bay *do* to now?

A. Presumably to the accumulation of sewage sludges on the bottom.

Q. Do you know of any contemplated dredging of Newark Bay to fill up the Newark meadows?

A. I believe there is a movement on foot, on the part of the Federal Government which might result in some such work as that.

Q. Would that increase the capacity of Newark Bay if it was dredged to any considerable extent and increase its diluting capacity?

A. So far as the incoming salt water is concerned, yes sir, but it would also lower the velocity of the flow out of the Bay and possibly allow of the deposit of offensive organic matter, such as is
3829 true in the case of New York, but such as will not be true in connection with the discharge of the Passaic Valley sewage, which is beyond the limits of possibility owing to the existing velocity of the channel in New York Harbor, and the velocities in the tanks where the sewage is treated in the treatment works near Newark.

In the report of the superintendant of the U. S. Coast Survey, 1873, page 129, the average velocity of flow of the tidal stream is given as 1.49 feet per second, as the maximum, and 0.29 feet per second as the minimum on the flood tide, and as 1.80 as a maximum and 0.52 per second as a minimum on the ebb tide. Observations made by the Metropolitan Sewerage Commission (report of 1910, page 155) give velocities as follows: maximum velocity 3.4 feet per second on the ebb tide, 2.7 feet per second on the flood tide, and the mean velocities are given as 2.07 feet per second on the ebb tide and 1.61 feet per second on the flood tide. It is unnecessary for me to draw attention to the fact that in the treatment tanks where the sewage of the Passaic Valley District will be retained for an hour or more the maximum velocity of flow in those tanks under the stipulation shall not exceed 0.625 feet per second.

Q. What has the velocity in the detention tanks got to do with the tidal current in Upper New York Bay?

A. They have this to do with them in my opinion:

It appears clear to me that the treatment given the sewage at the proposed works near Newark will result in the removal of all or practically — of those particles of suspended matter which will subside in one hour in a tank where the lineal velocity of flow does not exceed 6/100 of a foot per second; it is safe to say that at no time do the currents in New York Harbor show velocity anywhere near approaching this low figure; it seems plain to me, therefore, that such suspended matter as the sewage may contain as is
3830 discharged from the treatment works will never subside in the harbor but eventually be swept out to sea and permanently dispersed without nuisance.

Q. How long are sewage matters retained in New York's Upper Bay before reaching the outer waters of the ocean?

A. Some of the matters in New York sewage a large proportion of the suspended matters, are retained in New York Harbor indefinitely, according to the present method of discharge of sewage into New York Harbor.

Q. What velocity did you find in the current in New York Upper Bay during slack water?

A. The minimum harbor velocities through a complete vertical section may possibly average a somewhat lower figure than the minimum figure above given; slack water does not last for more than ten or fifteen minutes; that is the time of readjustment; at no time in the harbor, and especially is this true at Robbins Reef Light, is there any probability that there is no velocity of flow north or south.

Q. For how long a period during the 24 hours have you got slack water?

A. It is doubtful if anybody really knows because of the shifting currents at different depths in the harbor.

Q. The current velocities which you have given for New York Harbor for the year 1873, have those been altered or modified in any way that you know of?

A. I judge from the data which I have already read into the testimony as being secured by the Metropolitan Sewerage Commission in their 1910 report, that the velocities of flow, contrary to what naturally would be expected, have actually increased.

Q. When was the data that you refer to as collected by the Metropolitan Sewerage Commission gathered, during what year?

A. I presume in the year 1909, the year previous to the publication of the results.

3831 Q. When was the Ambrose channel opened for navigable purposes?

A. I do not know.

Q. Do you know whether or not it has altered the velocity of the currents in New York Harbor?

A. It is possible that it has diminished those velocities somewhat but the margin is too wide to make that a factor of significance.

Q. In relation to the condition that I directed your attention to a little earlier as to the absence of a tidal prism how would that affect those velocities?

A. If there is an absence of a tidal prism, which is a condition exceedingly hard to contemplate, these velocities will be altered materially; but the matters which might under these extreme conditions be deposited from the Passaic Valley sewage would be so small and so light that succeeding tides following the absence of tidal prisms would undoubtedly dislodge them from the harbor bottom and carry them out into the sea.

Q. How high does the underrun reach from the bottom of the main ship channel towards the surface of the bay?

A. I do not think it is possible to fix an absolute point.

Q. Approximately how high would it reach in the ship channel on an ebb tide?

A. On an ebb or an flood tide, Doctor?

Q. My question said ebb, and I ask you now if you can get an underrun of a flood tide?

A. There is no question about it.

Q. That you have an underrun and a flood tide at the same time?

A. Yes sir.

Q. What do you understand by underrun, Mr. Johnson?

A. I mean a current velocity at the bottom or near the bottom at any point beneath the surface that is greater than the surface velocity.

3832 Q. Do you have an underrun during the ebb tide?

A. It is possible.

Q. Do you know whether it is a fact or not in the ship channel in Upper New York Bay?

A. From the observations I have made on the question of the diffusion of salt water through fresh water, I think it is possible in a restricted sense to have an under current both on the ebb and the flood tide.

Q. Will you describe the under run which you said you made observations on, Mr. Johnson?

A. I have not said that I made observations on the underrun.

Q. Describe the under- as you understand it.

A. As the flood enters the harbor through the Narrows it is conceivable, due to the higher specific gravity of the salt water entering that that water will hug to the bottom or the lower strata, and so be carried a further distance north than the upper strata composed of fresh water or brackish water. At the northern most point and at the change of the tide, according to my inperpretation of the phenomena the surface will exceed in velocity the under run, and there will be a tendency to draw to the surface the under run and thereby effect the mixing.

Q. Have you now described an under run on the ebb tide?

A. I am setting forth my opinion as to the probability of there not being a very strong under current; it is very probable there is such an under run.

Q. Will you now describe the under run as you understand it on the flood tide.

A. That is just what I have described.

Q. Then will you describe the under run on an ebb tide?

A. It is my belief that on the ebb tide the swiftest

3833 currents are found normally at the surface and that the underrun, if such exists, as probably does, is flowing at a lower velocity than the surface current.

Q. And moving in what direction?

A. South.

Q. The underrun of the ebb tide moves south in New York Upper bay, is that correct?

A. If the water happens to be flowing south. But if you take as a fixed condition that the tide is in ebb when the surface water is flowing it is conceivable and probable that the salt water at the bottom, or the under current, may still be running north while the surface currents are proceeding south.

Q. Do the surface currents on the ebb tide and the under-run on the same condition of the tide, go in the same or opposite directions?

A. Just preceding and following a turn of the tide at the surface

they may be going in opposite directions; ultimately they run in the same direction.

Q. While they are running in opposite directions; how high in the ship channel does the underrun rise, what distance from the bottom of the seventy-five foot channel, if that is the depth, would the under run be found?

A. I could not tell you.

Q. You mentioned as a factor in dispersion in discussing the discharge from the Passaic Valley trunk sewer in New York's upper bay; I ask you how the one factor of the depth itself will aid in the dispersion?

A. It has a great deal to do with it; most sewer outfalls at the present time discharge at or near the surface of mean low water; it is the more common practice nowadays to locate the outfalls at a reasonable depth beneath the surface; that was done in connection with the Bronx Valley Sewer, and it is referred to repeatedly by the Metropolitan Sewerage Commission according to my understanding.

3834 Q. Will not sewage always rise no matter at what depth it is charged when discharged into brackish water?

A. Crude sewage, yes, sir. But I have already called attention to the fact that the diffusion of fresh water through salt water is very rapid.

Q. They reports which you introduced relative to the Metropolitan Sewerage Commission, were these preliminary reports?

A. They were.

Q. Have they been acted upon in any way?

A. They formed the basis, according to my understanding, for the final report; they are issued that their contents may be of early service without waiting for the publication of the

3835 final report.

Q. And commend methods for sewage disposal?

A. That is not the only place where reference is made to this method of putrification. I refer you to the regular report of the Metropolitan Commission of 1912, at page 69 and 70, where the following statement is made:

"It is evident from the studies made by the Commission that large quantities of sewage can be assimilated by the waters of the harbor without risk of creating offensive conditions and if the dangers — still lie in bacterial impurities be disregarded it will be possible to discharge large quantities of sewage from which the most objectionable matters have been removed, if into these waters without injury and with out excessive cost for public works." The Commission considers that in many parts of the city the construction of disposal works which makes use of the principles of screening and sedimentation in combination with outlets which will secure a prompt diffusion of the treated sewage in the water is the remedy now required, and that these works should be so built as to form a more extensive and composite plan for the exclusion of sewage from the harbor if greater protection should be needed in the future."

1936 Q. The matter which you have just now quoted from the Metropolitan Sewerage Commission report for 1912, and the other matters which you have alluded to as the preliminary reports, do these contain final details relative to sewage disposal or are they merely recommendations as to a line to be adopted towards a final system of sewage disposal.

A. That I do not know, but I do know that they are all that are required at the present time.

Q. Are there any details of the method of sewage disposal set forth in these reports that you have quoted from?

A. Only in so far as I have already read into the testimony.

Q. Have you made any estimate of the percentage of the cost that this tunnel would amount to that would transport sewage from the sewage disposal works at or near the Newark meadows to the outfall at Robbins Reef?

Mr. Riker: The question is objected to as immaterial and irrelevant, and as impertinent to the issue.

The Commissioner: Note the objection of counsel for the defendants.

A. Features of construction were outside the part in which I was interested in connection with the study of this problem.

Q. Do you find such a computation in the Hazen and Whipple report submitted to the city of Paterson?

A. They made such a computation I believe.

Q. Amounting approximately to what percentage of the entire cost?

Mr. Riker: I enter the same objection.

The Commissioner: Note the objection of counsel for the defendants.

A. I could not say.

Q. In that report was the degree of treatment recommended for the city of Paterson to adopt of a higher or lower grade than that adopted by the Passaic Valley Sewerage Commissioners for the
1937 treatment of the sewage to be discharged at Robbins Reef?

A. It is more complete and necessarily so because of the conditions under which it would have to be discharged.

Further redirect examination by Mr. Riker:

Q. Do you think that the substitution of a finer mesh for the 4/10 screen, would be a *useful* additional requisite?

Dr. O'Sullivan: I object to the question on the same ground as which Mr. Riker previously objected; that it calls for a judicial determination of a matter not within the purview or knowledge of this expert.

The Commissioner: Note the objection of counsel for the complainants.

A. I do not anticipate that such will be necessary for many years

to come in any event, still I believe it is perfectly within legal reason to substitute a screen of finer mesh if deemed necessary in the future.

Q. Do you know of any thing unlawful in such a substitution?

A. No sir.

Q. Do you think that additional sedimentation will be an additional lawful arrangement to that prescribed in the stipulation?

Dr. O'Sullivan: Note the objection of counsel for the complainant.

The Commissioner: Note the objection of counsel for the complainant.

A. No sir.

3838 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Name.	Direct.	Cross.	Redirect.
Charles A. Van Kuren	4127	4128	
Thomas H. McCann	4132	4133	
John Payne	(4139))4142(	4144	4156
John S. Gibson	4158	4162	

This volume contains the testimony taken during the latter part of the day on February 20th, and that taken on February 21st, and completes defendants' testimony on the main case.

3839 CHARLES A. VAN KUREN, a witness produced on behalf of the defendants, being duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. Riker:

Q. Where do you live?

A. Jersey City.

Q. What is your official position, if you hold one?

A. Chief Engineer of Jersey City.

Q. How long have you been such?

A. I have been their Chief Engineer for 15 years; prior to that I was assistant for 15 years.

Q. Have you or have you not had charge of the construction of the sewers of Jersey City?

A. I have.

Q. Are you familiar with the outfalls into New York Bay or the Hudson River?

A. I am.

Q. In making these sewers was the work under your charge as Engineer?

A. Yes, sir.

Q. In making such outfalls did you ever in any way or did anyone to your knowledge on behalf of your municipality apply to the State of New York, or to the City of New York for any permit or recognition of the rights you were exercising?

A. No, sir, not to my knowledge.

Q. In a general way the sewers of Jersey City are of the combined system, are they not?

A. Combined system.

Q. Have you ever heard of any claim on the part of the State of New York of any jurisdiction over the construction of outfall sewers into the Upper New York Bay?

3840 Dr. O'Sullivan: The question is objected to on the ground that this matter is not at all in issue or pertinent to the issue.

The Commissioner: Note the objection of counsel for the complainant.

A. I have not.

Cross-examination by Dr. O'Sullivan:

Q. How many trunk sewers empty or have their outfalls into New York Bay from Jersey City?

A. About, I should say, a dozen main sewers.

Q. What is the daily volume of sewage discharged from these main or trunk sewers?

A. About 46,000,000 gallons.

Q. What is the daily volume of trade wastes discharged by Jersey City into New York Upper Bay?

A. I never looked into that, I am not prepared to say.

Q. What is the character of the trade or factory wastes discharged into New York Upper Bay from the main or trunk sewers of Jersey City?

A. Generally manufacturing.

Q. Will you name some of these manufacturing plants whose trade wastes go into New York Upper Bay from Jersey City?

A. There are all kinds of manufactures there, there are iron foundries and like things, wooden ware construction and general trade of all description.

Q. Have you woolen mills?

A. No; silk mills.

Q. Have you got silk mills?

A. One silk mill.

Q. Have you any soap works in Jersey City that discharge their trade waste into New York Upper Bay?

3841 A. There is one, Colgates; what they discharge I am not prepared to state.

Q. How do you estimate the volume of sewage that is daily discharged into Upper New York Bay from the main or trunk sewer outfall of Jersey City?

A. I estimate the consumption of water.

Q. How much water does Colgates' soap factory use per day?

A. I cannot state that offhand.

Q. How much of that water does it get from the public water supply?

A. That is not in my department and therefore I would not be familiar with it; that is in the metre department, they take all these metre measurements; I am not familiar with that; but I can state that the railroads use one-quarter of the consumption.

Q. For what purposes?

A. For steam purposes and domestic as well, at their depots.

Q. They get their water supply from the public water supply?

A. Yes sir.

Q. And it is metered, is it?

A. Yes sir.

Q. Do you know if Colgates get any of their water from the public water supply?

A. I believe they do, I am not prepared to state; I should judge they did; they may have a well there.

Q. And whatever the volume of their trade wastes is would be estimated by you on the metre supply of the public water supply?

A. I did not say so; I did not know the conditions, I am not familiar with the condition there and therefore could not say sir.

Q. What I am trying to get at is how you estimate 46,000,000 gallons of sewage per day——

3842 A. I say that is our consumption of water, 46,000,000 gallons.

Q. 46,000,000?

A. Yes sir 46,000,000 I said.

Q. Is that the entire water consumption?

A. Yes sir.

Q. Do you regard the sewage discharge as equal to the water consumption and not exceeding it?

A. No, I say it exceeds it.

Q. By how much?

A. I cannot tell you that; I do not know how many wells they have and I have never entered into this matter to determine it.

Q. Do you know if any of those manufacturing plants use ground water for the purpose of their manufactures or whether they get water from wells?

A. There are some of them who use wells, driven wells.

Q. Will you name some of them?

A. I can name one and that is Lembeck & Betz, brewery.

Q. How much water do they use?

A. I don't know.

Q. Is brewery waste particularly objectionable as a trade or factory waste?

A. Not that I know of.

Q. Do you know anything about it?

A. Not about that, I am not prepared to state that; I am not engaged in the chemist business.

Q. Do you make a distinction between trade and factory wastes?

Mr. Riker: The question is objected to on the ground that it is not cross examination; Mr. Van Kuren has testified as an engineer to the construction of sewers, and nothing else.

3843 The Commissioner: Note the objection of Counsel for defendants.

A. I came here for that purpose and I am not prepared to state anything other than that.

Q. Have you made any special study of sewage or sewage disposal at all?

A. No sir, I have not arrived at that.

Q. Have you made any special study of bacteriology in connection with sewage disposal?

A. No sir.

Q. No biological examination?

A. No sir.

Q. Nor of chemistry?

A. No sir, I have not.

Q. And your estimate of the volume of sewage discharge is based on the supply of Jersey City?

A. And the water that they receive from wells.

Q. Have you made any estimates of that?

A. No sir, other than the consumption as I say, the consumption of 46,000,000 average; about 3/5 of that would enter the Hudson River.

Q. And that is how you make computation of its volume?

Mr. Riker: He has not said so.

A. As far as it goes, not beyond that, I have not gone into that matter; I so stated and therefore I am not competent to answer your question.

Q. Do you know whether or not your sewers are now running at their maximum capacity?

A. The maximum capacity? They are the combined system.

Q. Are they running at their maximum capacity?

3844 A. During a storm they will, if the magnitude of the storm is sufficient.

Q. What is the combined capacity of the 12 trunk outfall sewers you have described?

A. It will take a few figures to give you that, I am not—I have got to get my maps and the size of my sewers and make that calculation, but we calculate on taking care of certain rainfalls and the sewers are constructed of sufficient size.

Q. Are you sure whether or not the sewers at their outfalls discharge 90,000,000 gallons of sewage per day in New York Bay?

A. I am not sure, no sir.

THOMAS H. MCCAN, a witness produced on the part of defendants, being duly sworn by the Commissioner, testified as follows.

Direct examination by Mr. Riker:

Q. Where do you live?
A. Hoboken.
Q. What is your business or profession?
A. Civil Engineer.
Q. How long have you been engaged in that profession?
A. About 43 years.
Q. Have you had anything to do with the construction of outfall sewers from Hoboken and the territory on New York Bay North of Hoboken?
A. Yes sir.
Q. What connection have you had with that?
A. In the matter of designing and constructing practically all of the outlets North of the Jersey City line.
Q. Have you ever in that connection made any application to the State of New York or to the City of New York for any permit to discharge sewage into New York Bay?
3845 A. Oh, no, I never heard of such a thing.
Q. Have you ever heard of New York, either state or city, asserting any right to control the discharge of sewage into New York Bay on the New Jersey side?
A. No sir, I never met with any obstacles from anybody.

Cross-examination by Dr. O'Sullivan:

Q. How many trunk outfall sewers discharged into New York Upper Bay from Hoboken?
A. I will have to consult my notes, I can give it to you.
Q. Can you give me approximately the number?
A. Nine. I will make sure if you will let me look at my notes.
Q. Yes.
A. (After referring.) Yes, nine.
Q. What is their maximum capacity, those nine trunk outfall sewers?
A. Well, if you mean—tell me what you mean by the capacity, sir; I could not tell you what the sewers all actually discharge but I can tell you what they are provided for.
Q. What are they provided for?

Mr. Riker: The question is objected to as not cross examination?
The Commissioner: Note the objection of counsel for the defendants.

A. One way of answering your question is to say that these outlets are all on the combined system, that is they don't take sewage alone, they take sewage with running water and the amount of water is the index to determine the capacity; they are all generally based on discharge of an inch of rainfall per acre per hour.
3846 Q. What trade wastes do your trunk sewer- accommodate in Hoboken, going into the New York Upper Bay?

A. Practically all of whatever factories are there.
Q. What factories are there?
A. There are many factories of various kinds.
Q. Are their abbatoirs?
A. Sir?
Q. Are there slaughter houses?
A. No, I don't think there's a slaughter house North of—in fact I can swear there is not a slaughter house North of the Jersey City line and I think there are only one or two in Jersey City.
Q. Are there any woolen mills?
A. Woolen mills? Well there can't be very many.
Q. How many?
A. Well, there probably would not be—I cannot recollect a single one.
Q. What factories do you recollect that discharge their trade wastes through the Hoboken trunk sewers?
A. Hoboken? Well we have pencil factories, pocket-book factories and there is a large factory making surveyor's instruments, and so on, and there are toy factories and a great many factories, but they are generally small in Hoboken.
Q. Have you any machine shops?
A. Yes sir.
Q. What is the character of their trade wastes?
A. The trade wastes of a machine shop?
Q. Yes.
A. You mean from a sanitary point of view?
Q. From any point of view.
3847 A. I would not be prepared to answer that now, I would have to have some thought over that but I cannot fancy that it is very detrimental to health.
Q. Are there any acid trade wastes discharged from these machine shops?
A. Well, as far as Hoboken is concerned I don't think there are many machine shops in the city and they are very small affairs and it cannot amount to much if they do.
Q. What acids do they use in the machine shops?
A. I do not know, I am not an expert on that.
Q. Have you had any complaints against the outfalls of these trunk sewers in Hoboken?

Mr. Riker: The question is objected to on the ground that it is not cross examination and it is immaterial to this issue.
The Commissioner: Note the objection of counsel for the defendants.

A. Where the sewer empties at the physical bulkhead—you know there are two bulkheads, the physical and the legal line, and in cases where the sewers—and I think there is only one—empty at the physical bulkhead, at certain stages of extreme low tides there have been complaints.
Q. From whom?
A. From people in the neighborhood, but where we have got

the sewers extended to the pier line out into the current of the river, we have a very strong current in the Hudson River, especially on the Jersey City side, we have very deep water, 60 feet deep.

Q. Have any of the big steamship companies complained against your trunk sewer outfalls?

3848 A. No, because the North German Lloyd is the only steamship Company that is affected by the outlet and they have carried that outlet under their own piers at their own expense.

Q. How about the Hamburg-American line?

A. There is no sewers empty at the Hamburg-American line—oh yes, I beg your pardon, at the foot of Newark Street they have a *pase* in point; that should be carried out to the pier line and there would be no complaint.

Q. Have they not frequently complained of the offensive odor and the injury to the paint on their structures?

A. Yes sir, at those outlets, that is the only occasion.

Q. Can you give me any estimate of the volume of trade wastes and sewer discharged from these sewers in Hoboken into the Upper New York Bay?

A. No, I cannot differentiate the trade wastes and sewage from the combined flow of the sewer.

Q. I ask you to take the entire flow of the sewage, by whatever name you call it, and of whatever character it is that is discharged by these trunk sewers into New York Bay?

A. I answered that before, that it is equivalent to—at the maximum amount it is equivalent to an inch of rain per acre per hour.

Q. To what?

A. It is equivalent to the drainage of an inch per acre per hour, of the drainage area.

Q. How many acres do you count on in making that estimate?

A. East outfall has its own drainage area and those drainage areas vary.

Q. Taking that basis of computation, how much do you estimate the discharge from these trunk sewers into New York Upper Bay is?

A. Estimate what, the quantity of water?

3949 Q. The quantity of material that goes out through these trunk sewers.

A. All right—now if you take the Third street sewer of Hoboken, the drainage area of that sewer is not quite 800 acres; it drains one-half of that area so there are 800 cubic feet per second flowing from that sewer when it is doing its maximum work.

Q. And that is in addition to the regular sewage flow, is it not?

A. I do not get that.

Q. Is the item that you have just testified to in addition to the regular sewage flow?

A. Oh, the sewage flow, that is insignificant; it is the great bulk of rain-water that we have to provide for.

Q. What do you estimate the dry weather sewage flow accommodated by these Hoboken sewers and discharged into New York Upper Bay, to be?

A. The most conservative answer to that is that it will equal the water supply of the city. There is so much water going in and there must be so much water going out, that is the rough way to get at it. Now you want to know what that is, I suppose?

Q. Can you give it?

A. It is about 100 gallons per capita of the city.

Q. What is the population of the city?

A. Now it is somewheres about 70,000 I think.

Q. And there is no other water used by these factories or otherwise excepting the water that comes from the public water supply?

A. No. That is a maximum too, conservatively it should be taken at about 75 gallons per head.

Q. Do any of these factories get water from ground water or artesian wells?

A. Well, there are one or two. Hoboken is a poor place for wells.

3850 Q. How about ground water?

A. The leakage of ground water won't amount to much in Hoboken because our soil is quite porous.

Q. Have you installed your new sewerage system yet in Hoboken?

A. Council has adopted a new system, that is, they have adopted a system, they have never had a system before and now we have got one.

Q. Are many of these trunk outfall sewers little more than septic tanks now?

A. Oh they are not septic tanks, not the outfalls, the outfalls are—we find them clean, they flow good; some of them have been improperly constructed in former times and these sometimes become stagnant.

Q. Don't they clog up some distance back from the outfalls themselves?

A. There are some of them that are not on a proper grade; of course to answer that question you would have to have a map here, showing every street and every sewer.

Q. On several are not the grades reversed?

A. Sometimes.

Q. You have had numerous complaints about the odors from these sewers have you not?

A. In the outer district it is in Hoboken the same as in any other city, where they don't have proper outfalls, they will complain.

Q. Who else has complained of injury to their property besides the Hamburg-American line, arising from the offensive odors and discharges from the trunk sewers of Hoboken?

A. Nobody that I know of. There were some complaints from the Delaware & Lackawanna Railroad but that is outside of

3851 the city line, if you know where Ferry street is, there are three or four sewers running from that into the old canal; the city has acquired rights to it; that canal is a shallow basin, a long shallow basin and it became on account of sewage going into it foul, and that has been rectified now.

Q. Who else beside the Lackawanna Railroad.

A. That was not a complaint, the city had a right to go there, the railroad company had to put up with it.

Q. They had to stand it?

A. Until it was rectified.

Q. Who was the consulting engineer employed by the City of Hoboken to advise them on the installation of a new sewage system to displace this defective sewage system you have testified to?

A. Mr. James—I have forgotten his middle name—Fuertes.

Q. Mr. James H. Fuertes?

A. Yes sir.

Q. Have you read his testimony in this case?

A. No sir, I did not know he testified.

Q. Did you graduate as a civil engineer?

A. From Cooper Institute night school.

Q. How long have you been in Hoboken?

A. Since about 1870.

3852 JOHN PAYNE a witness produced on behalf of the defendants having been sworn by the Commissioner testified as follows:

Direct examination by Mr. Riker:

Q. Where do you live?

A. Jersey City.

Q. What official position do you hold?

A. I am secretary and Engineer of the State Board of Riparian Commissioners of New Jersey.

Q. How long have you held that position?

A. About seventeen years; thirty five years, as Assistant Engineer and about seventeen years as Secretary and Engineer, the latter seventeen years.

Q. Are you familiar with the methods of procedure of that commission?

A. Yes sir.

Q. What do they do with reference to filing lines of solid pier filling and lines for pier heads in New York Bay on the New Jersey side?

A. They have fixed such lines after making surveys of the waters and have changed the lines at different times, since 1865 when the first line was fixed.

Q. In that connection do they apply for any permit or authority or approval of the State of New York or any municipal body in the State of New York.

A. No sir.

Q. Do they apply for the authority of any body with reference to that matter?

A. No sir.

Q. Have they from time to time fixed lines of——

A. I beg your pardon; in the case of fixing lines around the reefs and shoals, under an act of the Legislature, in New York Bay

under an act of the Legislature, it is first necessary to apply
3853 to the Secretary of War for approval of the lines suggested.

Q. Do you know whether the Riparian Commissioners and the Governor have made any grant to the United States of land under water in New York Bay.

A. Yes sir.

Q. Where?

A. On February 14, 1880 the State of New Jersey made a grant to the United States Government of ten acres surrounding Robbins Reef Light in New York Bay; on November 30, 1904, the State of New Jersey made a grant to the United States Government of land surrounding Ellis Island.

Q. Have the Commissioners fixed lines of solid filling in New York Bay on the New Jersey side?

A. Yes sir.

Q. Have filling been made out to that line so fixed?

A. Yes sir.

Q. Where, in what instances?

A. Nearly the entire front from Fort Lee, and indeed above Fort Lee but nearly the entire Hudson River front from Fort Lee to Constable's hook has been granted by the State of New Jersey and a great part of it has been filled to the solid filling line and piers built to the pier head line and occupied by the various steamship lines and commercial enterprises doing business on that shore.

Q. Has any permit or approval on the part of the State of New York for any of those actions been given?

A. No sir.

Q. Has there been any remonstrance by the State of New York, or by any municipal bodies in New York, so far as you know, to this course?

A. No sir.

3854 Q. Have you a map with you, showing the lines dividing the State of New Jersey from the State of New Jersey?

A. Yes sir I have one of the copies of the map filed with the report of the Commissioners of 1887 showing the boundary line in New York Bay, the Kill Von Kull and a part of Newark Bay.

Q. Will you look at this map and tell me what line on that map indicates the dividing line between the State of New York and the State of New Jersey and described it, either as a dotted line or a solid black line, or whatever description you think will identify it.

A. The line dividing the State of New Jersey from the State of New York in New York Bay begins at a point mid-way between the Central Railroad Terminal at Jersey City, and the Battery at the lower end of New York Island, and is marked on this map K. or A.A. at a point enclosed by a triangle. The line is shown as a full black line running southwest to a point between the Bay Ridge and Staten Island and about southwest from Robbin's Reef Light and is marked by the letter J. Prime, and is a point enclosed by a triangle; the line then runs in a pretty nearly westerly direction and is indicated by a full black line to a point between Constable's

Hook and Brighton, Constable's Hook in Bayonne and Brighton in Staten Island, and is indicated by the letter I. prime and is a point enclosed by a triangle; that is the mouth, from the New York end, of the Kill Von Kull.

Mr. Riker: I offer this map in evidence.

The Commissioner: That will be marked defendant's exhibit 4.

Dr. O'Sullivan: I should like to examine the witness about the map before it is marked.

Dr. O'Sullivan:

Q. Who prepared this map?

A. The Commissioners indicated on the map: M. W.
3855 Haseltine, Robert Moore, G. C. Hannis, New York Commissioners, R. C. Bacot, William Olliver and E. A. Stevens, New Jersey Commissioners; and it *id* marked "Map showing line agreed upon filed in the office of the Secretary of State of New York," and under the New Jersey Commissioners "Map showing line agreed upon filed in the office of the Secretary of State of New Jersey."

Q. When was that boundary line adjusted?

A. As indicated on the map and written "Agreed upon by the Commissioners appointed by the Governors of their respective States, on December 23, 1889."

Q. Was that boundary line ratified, by the Federal Government in any way?

A. I do not recall that it was, sir, although my impression is that the maps were filed at Washington.

Q. Does that differ from the boundary line that existed in 1833?

A. No sir, it is the definition of the boundary line fixed by the Treaty in 1833.

Q. And is identical with it as far as you know?

A. Yes sir.

Q. Have you compared the copy of the map that you have produced here with the original.

A. Yes sir.

Q. And find it how?

A. An exact copy.

Dr. O'Sullivan: I make objection to the map on the general ground that it is irrelevant.

The Commissioner: Note the objection of counsel for the complainant.

(Map marked Defendant's exhibit 4.)

Further direct examination:

Q. In connection with your duties as Secretary and En-
3856 gineer for the Riparian Commissioners have you familiarized yourself in any way with the shipping and shipping interests along the New Jersey Shore on Upper New York Bay?

A. Yes sir our commission is generally familiar with the fact of the existence of the interests, without going into the extent of details of their business.

Q. Are there trans-Atlantic steam ship lines that dock on the New Jersey Shore?

A. Yes sir a number dock at Hoboken; the principal ones are the Hamburg-American, the North German Lloyd, the Scandinavian Line, I think, and the Holland-American Line, and two or three other lines the names of which do not occur to me at this time, and at Jersey City there is now an Italian Line, docking at the Pennsylvania Piers.

Q. Along this shore are there or are there not a number of important Railroad Terminals?

A. Yes sir, the New York, Susquehanna and Western have their terminal on the Hudson River, at Edgewater, about opposite Grant's Tomb; the New York Ontario and Western have a terminal; the West Shore Railroad have their extensive terminals on the shore at Weehauken; the Delaware and Hudson Canal Company have, or had their coal terminal; the Delaware, Lack-wanna and Western Railroad have their terminals below Hoboken; the Pennsylvania Railroad has the property which was used until recently as their terminal, and the Lehigh Valley have their Railroad has its terminal at Jersey City; the Central Railroad of New Jersey has its entire terminal at Communipaw; the New Jersey Junction Railroad has its Warehouses and terminals below Jersey City; the Pennsylvania Railroad has its freight terminals at Greenville, in Jersey City on New York Bay.

Q. Are there important manufacturing interests or factories located along the shores of New York Bay on the New Jersey
3857 side that you know of?

A. Yes, there are at least two important sugar refineries, one is the Knickerbocker Refining Company and the name of the other I do not recall. Pyles Pearline Company have an extensive factory; the chemical interests have two or three important factories; the lumber interests have distributing depots at Hoboken and at Jersey City.

Q. Is Colgate's Soap factory there?

A. Colgate's Soap factories are back from the River a short distance, but distribute by loaded cars, directly onto the boats at the River front.

Q. Is there any considerable interstate commerce by water carried on from the New Jersey shore?

A. Yes sir.

Cross-examination by Dr. O'Sullivan:

Q. When you want to extend your pier head line to whom do you apply for permission?

A. The State extends its pier head line of its own volition or desire, but it is necessary before that is operated, under the Government, for the Government, to approve that line, and the commission applies to the Secretary of War for conference in the adoption of any line that they desire to establish.

Q. By "Government", when you use that term, what do you mean, what Government?

A. The United States Government?

Q. Can you extend your pier head line indefinitely without permission from the Federal Government.

A. The state could, but it would not be operative, or would not be permitted, possibly, by the United States Government, until the Secretary of War had approved that extension.

3858 Q. Have you not get applications now before the Secretary of War for the extension of piers and desiring his permission before you undertake the work of extending those piers?

A. No sir, not now. The Government had—the Secretary of War—the commission had an application before the Secretary of War and that application was not concur-ed in but recently, on February 5th, the Secretary of War fixed a line that he did approve, and last Monday the Governor and Commissioner adopted that line approved by the Secretary of War, February 5, 1913.

Q. Would your State be permitted to extend these lines despite his denial permission.

A. Yes sir, our State would have the power to extend the line but it would not have the power to enforce a construction out of that line, I think, in opposition to the dicta of the Secretary of War.

Q. Is not his dicta final in relation to navigable water no matter whether within a State or interstate.

A. Yes sir, the State of New Jersey so regards it.

Q. That would hold good on the Passaic River which is entirely within New Jersey territory?

A. Yes sir.

Q. Relating to that boundary line, and the compact between the states in 1833 do you know if any other matter relating to the states' jurisdiction over Upper New York Bay was settled in that contract, other than the boundary line?

A. I do not recall; my impression is, however, that the duties of the Commission appointed, and who made that map, were simply to settle definitely and geographically the location of the line and not other questions.

Q. What year are you talking about now?

3859 A. 1889, the date of the actual defining of the line referred to in the Treaty of 1833.

Q. My question related to the treaty or compact of 1833, whether any other matters relating to interstate or state jurisdiction were settled in that compact other than the boundary line.

Mr. Riker: The question is objected to on the ground that Mr. Payne has not attempted to qualify as an expert in law, and that the interpretation of the compact between the States, does not depend upon any expert witness or other witnesses, that the question of procedure under it and facts of the procedure may be relevant, but the opinion of a witness on the legal affect of the compact is not competent.

The Commissioner: Note the objection of the counsel for the Defendants.

Dr. O'Sullivan: The question is precsd by counsel for Complainant on the ground that the map produced here and offered in evidence is merely a registering of a line which was determined in 1833, and was only part of a compact, or of the work done by the commission in 1833, and for the purpose of testing this witness'es memory, as to what other portions of that compact were, and how they related to this boundary line and kindred matters.

A. I am not competent to answer that question.

Q. As a matter of memory do you know whether or not there were other matters in the compact defined besides the boundary line.

Mr. Riker: The question is objected to as not being a proper subject to test the memory of any witness.

The Commissioner: Note the objection of counsel for the defendants.

A. I am speaking from my impression, from my—my impression of my recollection, perhaps, that there were questions of
3890 jurisdiction, perhaps, or other questions, than those relating to the location of the line, but I may be speaking only from a recollection, not derived from the treaty at all, but from subsequent reading or discussion.

Q. How was that boundary line determined in 1833?

A. I cannot give the description, sir, definitely, from recollection, but it was a general boundary line, and the nature of the description, gave rise to differences of opinion, and the definite fixing of the line in 1889 was to clear up those differences of opinion.

Q. How was the line fixed in 1889, the boundary line between the states?

A. I cannot say that I understand your question, do you mean what method was used?

Q. How was it determined, how was its exact location determined?

Mr. Riker: If you know?

A. I only know by some slight connection, some little work with the work of the commissioners, I had some work in it; they took the map, for instances, showing—they took the Government map showing the high water line of 1833 and from that located a line as a boundary line that in the judgment of the commissioners followed the description in the treaty of 1833.

Q. Were you connected with this commission that you represent here now, in 1889.

A. Yes sir.

Mr. Riker: I think the form of that question if objectionable; he does not represent the commission here, now.

Witness: I beg your pardon, do you mean the Riparian commission?

Mr. Riker: He does not represent the commission; he is
3861 here as an individual who happens to be the secretary of the commission; the commission is not here officially.

Q. Are you appearing here as a witness, as Secretary of the Riparian Commission, or simply *or* in a private capacity as Mr. Payne?

A. In a private capacity, as Mr. Payne, sir.

Q. And you disclose knowledge which came to you through being Secretary of the Riparian Commission, is that right?

A. I have given information, yes sir, that I have gained as Secretary of the commission.

Q. And the map you produced here, how did that come into your possession?

A. That is one of a great number of copies of the boundary line map that were distributed gratuitously, by the State authorities, and I, in common with any other citizen that desire it may have copies of them, and I have some copies of that map.

Q. And the copy you produce here you procured in your capacity as a private citizen?

A. Yes sir.

Q. And then as Secretary of the Riparian Commission you compared the map which you got as a private citizen, with the original map which was in your custody as Secretary of the Riparian Commission. Is that right?

A. I had previously compared one of these maps with the original map and knew that it was an exact copy.

Q. Did you compare this particular copy of the map offered here today?

A. I compared this map that is offered to-day with the copy I had compared previously with the original map, and it is the same.

Q. In whose possession was the copy that had been com-
3862 pared with the original?

A. That is in the possession of the Riparian Commission.

Q. Have you access to their maps?

A. I have the custody of their maps.

Q. So that you could have compared it with the original as well as with the compared copy.

A. Yes, but the original is in a tin case, and a little difficult to get at, so I saved myself the trouble of taking it out or getting it out, and reached the result I have stated.

Q. Where was the original prepared, in the State of New Jersey or in the State of New York.

A. It was prepared in the State of New Jersey.

Q. And in fixing the lines what metes and bounds or other matters were taken to define the boundary line?

A. A very elaborate system of metes and bounds was used and are set forth in the report of the commissioners to the Legislatures of the two states, and filed in the Secretary of States' offices and also published in the report of the Riparian commission of New Jersey in 1891, giving the location of each of the angle

points that I have merely referred to by letter, on the map, under discussion.

Q. So that Mr. Payne, this map which you have produced here has rendered and defined the boundary line as determined in 1833.

A. Yes sir.

Q. Do you know whether it follows the filum aquæ?

A. Yes sir, that was one of the points that the New Jersey commission and Mr. Robert T. Bacot, the engineer of the Riparian Commission then and a member of the boundary commission prides himself on as having secured that for the state of New Jersey.

Q. So that if the Channel should change its course, the
3863 boundary line would follow the changed channel line.

A. I cannot say as to that.

Q. Your connection dates from when, what year, with the Riparian commission?

A. 1877.

Q. Since 1877 had New Jersey at any time to your knowledge exercised police or quarantine jurisdiction over New York Upper Bay?

A. I cannot say as to that, I am not familiar with that subject.

Q. Are those matters which in any way interest the Riparian commission.

A. I presume, sir, you mean interest them officially?

Q. Yes.

A. I do not think so, excepting that I think if an application were made and it was disclosed that the property was to be used for a purpose detrimental to the interest of the community and State, the Government and the Commission would take cognizance of it in the consideration of the application.

Q. What is the objective of quarantine jurisdiction?

Mr. Riker: If you are an expert and know.

A. I am not competent to speak understandingly of the subject.

Q. Does it relate to property Riparian Rights or to health?

Mr. Riker: If you know.

A. I should say generally it refers to health.

Q. You mentioned something about the sugar interests.

Mr. Riker: The what?

Q. The sugar factories; do you know anything at all about such trade wastes.

Mr. Riker: The question is objected to on the ground
3864 that the witness has said nothing whatever about trade wastes or sugar wastes, and that the question involves a mis-statement of his testimony.

The Commissioner: Note the objection of counsel for the defendant.

A. If I may say, I do not recall mentioning anything about the

process of manufacture of sugar but merely intended to speak of the location of the sugar industries on the shore.

Q. Are you a Civil Engineer?

A. No sir, I acquired my knowledge by practice.

Q. Do the Riparian Commission take under their observation and notice trunk sewer outfalls along the Ripa?

A. They do now, sir, and where there is an application, for such sewer outlets the matter is referred to the State Board of Health, for advise and suggestion.

Q. How many trunk sewer outfalls discharge into upper New York Bay from Jersey City, Weehawken, Hoboken, and Bayonne?

A. I could not tell you, I have no knowledge on that subject.

Q. Can you give me any approximate number.

Mr. Riker: The question is objected to on the ground that it has already been answered, and on the further ground that the witness was not examined on the direct examination, on any subject connected with sewer outfalls.

The Commissioner: Note the objection of counsel for the defendants.

A. I could not give you any answer that would not be a mere guess, and which would be valueless as information.

Q. Do the Cities that I have named, Mr. Payne have to get permission from the Riparian Commission before building and
3865 operating a trunk sewer that is discharging at the pier head line or the bulk head line.

A. They do, sir, if they have not either themselves, under their own authority acquired the Riparian rights or gotten permission from those who have acquired the Riparian rights, and that is only as to the occupation of the land for some structure, not so much as to the use of the structure.

Q. In giving permits of that kind, is it necessary to know whether or not in that immediate neighborhood there are a large number of like structures?

A. As to that I think my previous answer, that the commission referrs such matters to the State Board of Health for advise and suggestion, covers the present question.

Q. Does your commission design, or pass upon the design, of, the piers used by the big Liners that you have mentioned.

A. No sir, the State has no authority over the plan of construction, excepting that in the grant it is stipulated that between the bulk head line and the pier head line, piers alone shall be built.

Q. If those piers are to be extended out, they apply to your commission for a permit.

A. May I ask—extended?

Q. Toward the main ship channel.

A. Beyond the existing pier head line?

Q. Yes.

A. That would not be the procedure; they would apply for the extension of the pier head line, and then, if their conveyance was of that character, their rights would go out automatically, but

that would depend on the character of their conveyance, *their* being three different kinds of State grants in use, since 1869, when the State began to make State grants through its Riparian Commission.

3866 Q. For instance, if the Hamburg-American line wished to extend its present piers, to whom would it apply for a permit for the extension, I mean in the direction of the main ship channel?

Mr. Riker: The question is objected to on the ground that it is not definite as to what extension is referred to, whether it is beyond the present existing line, or the pier head line fixed by the State Board.

The Commissioner: Note the objection of counsel for the defendants.

A. May I ask that you will define to what line, you refer in your question of extension?

Q. To any line that bounds the present pier, the extending of their present line, to whom would they apply for permission to make the extension, that extension being in the direction of the main ship channel?

A. That is a question that I am not competent to answer, because in the discussion that came up before the Governor and the Riparian commission last Monday on the application of the Hamburg-American line for the adoption by the State Riparian Commission of the line fixed or aproved by the Secretary of War on February 5, 1913, the question of the rights of the Riparian grantee were not passed upon, but were left in obeyance, and I am not competent to answer the question.

Q. Who presented those requests for extension to the Secretary of War, was it your commission?

A. I am not sure that I understand your question, sir the request for what?

Dr. O'Sullivan: Strike out the question.

3867 Q. Mr. Payne, you have just described in your testimony requests for pier extensions that have been passed upon by the Secretary of War; I ask you who submitted the requests for those permissions to the Secretary of War, whether it was your commission, or whether it was some other commission.

Mr. Riker: The question is objected to on the ground that it involves as a statement of fact something that has not yet appeared on record, that there was any application by the commission to the Secretary of War.

The Commissioner: Note the objection of counsel for defendants.

A. That question is not clear to me, and it seems to involve two transactions, I do not wish to be captious, but the requests for the adoption by the Riparian Commission of the extension of the pier head line approved by the Secretary of War, February 5, 1913, was a request for the adoption of the line in its entirety, and not for the

extension of any piers, but was made by the Hamburg-American line and was for the adoption by the State of the line approved by the Secretary of War.

Q. Does your commission, the Riparian Commission, pass upon these applications in the first instances.

Mr. Kiker: The question is objected to on the ground that it is indefinite, it does not appear what applications are referred to.

The Commissioner: Note the objection of counsel for the defendants.

A. May I ask you, sir, to define what applications you refer to?

Q. What applications did the Secretary of War pass upon, in February or in any other month of this year so far?

Mr. Riker: If you know.

A. They were the applications of the steam ship interests and—I am speaking from general knowledge as well as some particular knowledge—of the general, commercial and maritime interests of the Port of New York and were supported by the municipalities of the two states and were also supported by the application of the State of New Jersey through its Riparian Commission to this extent, that if any extension of the line on the New York side of the Hudson River was allowed by the Secretary of War, a similar extension of the line should be allowed to the State of New Jersey on the New Jersey side of the Hudson River, and this course has been adopted by the Secretary of War in his approval of the line of February 5, 1913.

3868

Q. Through what commissions were these applications transmitted to the Secretary of War?

A. As far as the Riparian Commission is concerned, the application or request was transmitted directly to the Secretary of War, as my general knowledge is that all applications are, it is a matter of practice that they must go to the Secretary of War first and then are referred by him to his Advisory Board, the New York Harbor Line Board.

Q. Do you know whether or not there is a joint commission from the States of New York and New Jersey, known as The Commission for pier extension and Harbor improvements in the Harbor, meaning the Harbor of New York.

A. Yes sir, I believe there is such a commission.

Q. Does the Riparian Commission co-operate with that joint commission, or is it practically entirely separate and distinct?

A. I do not know of any other way that the Riparian Commission has co-operated with that commission except in furnishing any information as to existing locations or lines or in any other way that the New Jersey Commissioners have requested them to make.

Q. The information at the disposal of the Riparian commission has, at all times, has it not, been at the disposal of the joint commission, that is the end of the joint commission relating to the State of New Jersey?

3869

A. Yes sir.

Q. Mr. Payne, how near to the boundary line, that you have described on the map that has been marked in evidence are the trunk outfall sewers of Bayonne, Jersey City, Hoboken and Weehawken?

A. Those distances vary greatly, because I have described only the boundary line in New York Bay, and the outlet of the sewers in Weehawken would be miles and miles up the river from the line I described. I do not mean to be captious, but you can see the point.

Q. Do those trunk outfall sewers discharge at high or low water marks?

A. I am not competent to answer that, so that if would be of any real information.

Q. How near the boundary line is the trunk outfall of this Passaic Valley Trunk Sewer project?

A. I do not know the location of the outlet of the trunk sewer and it is not marked on the map.

Redirect examination by Mr. Riker:

Q. You were asked about a joint commission on pier and harbor lines, I think it was called.

Dr. O'Sullivan: Pier extensions and Harbor Improvements.

Q. Pier extensions and Harbor improvements, do you refer in your testimony *of* the New Jersey Harbor Commission?

A. Yes sir.

Q. That is the commission you referred to?

A. Yes sir.

3870 Q. That is the commission you referred to, the New Jersey Harbor Commission, is it not?

A. In connection with the New York Commissioner, as the joint *joint* commission.

Q. Do you know as a matter of fact whether there is any joint commission?

A. Yes sir.

Q. You think then, that this commission is simply to act jointly with a similar body of New York, and a Federal Commissioner in the investigation of the Ports of this country and abroad.

Dr. O'Sullivan: The question is objected to as clearly a cross examination by counsel of his own witness.

Mr. Riker: Of matters you brought up yourself.

Commissioner: Note the objection of counsel for complainant.

A. I understand that is the promise of the commission.

By Dr. O'Sullivan:

Q. Which commission did your answer contemplate?

A. The joint commission, that on the part of New Jersey, and three commissioners on the part of New York together with a Federal Officer to complete the commission.

At this point the further taking of testimony on the part of the defendants was adjourned until Friday the 21 day of February, nineteen hundred and thirteen at 10:30 A. M. at the office of Messrs. Riker & Riker, Newark, N. J.

3871 Supreme Court of the United States, October Term, 1911.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and THE PASSAIC VALLEY SEWAGE COMMISSIONERS, Defendants.

Taking of Testimony at the Office of Messrs. Riker & Riker, Newark, N. J., Friday — 21, 1913, 10:30 A. M.

Before: James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esq., Attorney General of the State of New York;
William A. McQuaid, Esq., Deputy Attorney General;
Dr. William J. O'Sullivan, Special Counsel for the People of the State of New York, Complainants.
Edmund Wilson, Esq., Attorney General of the State of New Jersey;
Robert H. McCarter, Esq., of Counsel for the State of New Jersey;
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

JOHN S. GIBSON, a witness called by the defendants being duly sworn by the Commissioner, testifies as follows:

Direct examination by Mr. Riker:

Q. Where do you live?
A. In the city of Newark.
3872 Q. Have you any official connection with the Passaic Valley Sewerage Commission?
A. Clerk for that body.
Q. How long have — been its *check*?
A. Since its inception in 1902.
Q. I hand you a paper dated New York, March 15, 1909, purporting to be signed by Rudolph Hering, George W. Fuller and Edlow W. Harrison, and ask you if you have had the custody of that paper.
A. Yes, sir; I have had the custody of this document.
Q. Are you familiar with the signatures of Rudolph Hering, George W. Fuller and Edlow W. Harrison?
A. I am.
Q. Are the signatures to that paper the signatures of those gentlemen?
A. They are; yes, sir.

Mr. Riker: I offer this paper in evidence.
Dr. O'Sullivan: I object to the admission of this paper to evi-

dence, as it has not been proven, or any proper grounds laid for its admission.

The Commissioner: Note the objection of Counsel for the complainants.

Marked Defendants' Exhibit 5.

Q. Do you know whether a contract has been entered into between the Passaic Valley Sewerage Commission and certain municipalities lying within the district?

A. I do; yes, sir.

Q. What is it? Do you know the date?

A. September 20, 1911.

Q. Can you give the titles of the parties to the contract?

A. Yes, sir. The city of Newark; the town of Belleville; the town of Nutley; the city of Passaic; the township of Acquackanonk; the city of Paterson; the borough of Garfield; borough of Wallington; East Rutherford; Rutherford; the township of Union; borough of North Arlington; the town of Kearney; borough of East
3873 Newark, and the town of Harrison—fifteen in number.

Q. I show you a paper dated May 11 1910, purporting to be signed by J. M. Dickenson, Secretary of War, having annexed to it two photographic reproductions of plans, and a paper purporting to be a copy of a stipulation in this suit, dated the fourteenth day of April, 1910, and ask you whether you have had the custody of that paper.

A. I have.

Mr. Riker: This being the original permit from the Department of War for the construction of this sewer, I propose offering a copy of it certified by the War Department, and I now make that offer, substituting for it a copy made in this office, which I will now offer, and later a certified copy by the War Department, which I will ask to have marked Defendants' Exhibit 6.

Dr. O'Sullivan: Before you mark that in evidence, I would like to ask a few questions of the witness.

By Dr. O'Sullivan:

Q. Where did you receive the document, Mr. Gibson?

A. It came to me, I think, in the course of business while in the office; I couldn't exactly tell, it was handed over to me as one of the official documents of the Commission.

Q. Have you compared the copy that Mr. Riker offers in evidence, with the original document?

A. I have not.

Dr. O'Sullivan: I make formal objection to the document being received at this time as it has not been properly proved.

The Court: Note the objection of Counsel.

Mr. Riker: I may state that my purpose will be, as I said, to substitute the certified copy of the War Department; and I will, if you desire, so far as this particular instrument is concerned, I can have my office force certify that this is an examined copy in

this office, and I only put this in subject to your examina-
3874 tion—a copy of the paper at this time.
Marked Defendants' Exhibit 6.

By Mr. Riker:

Q. Now, Mr. Gibson, I show you a second paper, bearing date the twenty-second day of September, 1911, purporting to be signed by Robert Shaw Oliver, Acting Secretary of War, and marked on the back "Office Secretary War Department, September 21, 1911, $\frac{17201''}{-061}$ and also "Office Chief of Engineers, War Department, September 22, 1911, $\frac{220103''}{198}$ and ask you whether that paper has been in your custody as Secretary to the Commissioners.

A. Yes, sir, that paper has been in my custody.

Mr. Riker: I propose substituting for a copy which I produce here, a certified copy of that paper, and meanwhile I will put in, for the examination of Counsel, a copy which has been examined in this office, a true copy, and will substitute later a true copy. The reason why the original papers produced are not placed in the exhibits is that they are original official documents from the War Department authorizing the construction of this sewer and its discharge into New York Bay and that if they are put in as exhibits they are taken out of the files of the Commissioners. I am offering now and ask the Commissioner to mark as Defendants' Exhibit 7, the office copy which I produce of this particular paper, with the understanding I will substitute a certified copy from the War Department in its place.

Dr. O'Sullivan: I make formal objection to the admission of this document on the ground that it has not been properly proven, nor proper grounds laid for its reception as evidence in this case.

The Court: Note the objection of Counsel.

Marked Defendants' Exhibit 7.

3875 Cross-examination by Dr. O'Sullivan:

Mr. Gibson, this first paper that was offered in evidence——

The Commissioner: Defendant's Exhibit No. 5.

Q. The Hering Letter—the Hering-Fuller-Harrison letter of March 25, 1909, have you any knowledge of the truth or accuracy of the statements contained in that document, which is dated New York, March 25, 1909, and signed by Rudolph Hering, George W. Fuller and Edlow W. Harrison?

A. I have not; no, sir. I am not familiar with the things treated.

Q. Directing your attention to page 3 of that document, under the caption "Estimated degree of removal of floating and suspended matter" I ask you whether or not you know to be true the statement "The very finely divided, suspended, organic particles and dissolved organic matters in the sewage will, under the proposed con-

ditions of dispersion, be carried into the water until they are adequately oxidized, or mineralized, or consumed by low forms of marine life."

A. You ask me what, in reference to it?

Question repeated.

A. I do not; no, sir. Not familiar with the subject at all.

Dr. O'Sullivan: That is all.

The Commissioner: Shall we adjourn, subject to the call of Commissioner?

Dr. O'Sullivan: Mr. Riker has something to say? Does the defendant rest?

Mr. Riker: The defendant has no further evidence today. If further evidence is to be put in, they will try to arrange for a further hearing before the first of March. My belief is that we shall not desire to offer any further evidence.

Dr. O'Sullivan: I understand that the defendant rests?

Mr. Riker: Unless we put in further evidence before the
3876 first of March, the Defendant will have rested.

The Commissioner: We will adjourn, now, subject to the call of the Commissioner on notice from Counsel for both sides.

Whereupon, at 11:30 A. M., the Commissioner adjourned the hearing, subject to call.

3877 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, May 19th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

Thomas Carmody, Esq., Attorney General of the State of New York;

Dr. William J. O'Sullivan, Special Counsel to the People of the State of New York, Complainants;

Edmund Wilson, Esq., Attorney General of the State of New Jersey;

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

The Commissioner: Pursuant to the notice heretofore served on Counsel by the Commissioner, testimony for the Complainants in rebuttal was begun.

JAMES J. POWERS a witness called in behalf of the Complainants in rebuttal, being duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Mr. Powers?
A. James J. Powers.
Q. Where do you reside?
A. 901 Madison Avenue, Elizabeth, New Jersey.
3878 Q. What is your business, Mr. Powers?
A. My business is contracting engineer in sanitary and hydraulic work, and specialist in sewage purification.
Q. What sewage disposal works have you ever installed and operated?
A. Brighton Beach, Coney Island, in 1879; West Brighton Beach, Coney Island, 1885 to 1889; Viriginia Beach, Virginia in 1890; White Plains, New York, 1890 to 1892; Sheepshead Bay, New York, 1890 to 1892; Seville, Florida, 1888; Round Lake, New York, 1888; Far Rockaway, New York, 1896-1897; Brooklyn, New York, 26th Ward, 1895; Bath, New York, Steuben County, 1895; sewage purification works, New York State Soldiers and Sailors Home; also sewage purification and water supply at Davenport Orphans Home. Honesdale, Pennsylvania, sanitary inspection, disinfection and improvements during the following typhoid fever epidemic in 1887. Brooklyn City, 1884: Chief Inspector of drainage and plumbing, Department of Health, City of Brooklyn, and (1882-1886) Examiner of Plans for sewerage and in charge of visiting inspectors in infected district during typhoid fever epidemic in 1884 and premises to which infectious diseases recurred or prevailed from 1874 to 1886. Fire Island, 1898: In charge of sanitary construction and repair at Fire Island preparing camp for sick soldiers of New York State invalided from the Spanish War in Cuba. Mount Vernon, 1898: Engineer in charge of sanitary improvement of sewers and water supply at Mount Vernon, New York, Infants Asylum, following outbreak of dipetheria. Jamaica, Borough of Queens, 1901: Sewage purification works at Jamaica, Queens Borough, New York,—Sewage disposal and sanitery works at isolated places in Florida, New Hampshire, Vermont, Connecticut, New Jersey, Rhode Island, Pennsylvania, New York and Ohio.
3879 Q. Now, what sanitary work have you been engaged on since 1872?
A. My practical construction experience in sanitary work began in 1872 and since that time I have been actively engaged in practical work. In 1881 I invented and patented the first method of antiseptic sewage treatment and dispersion by subsoil irrigation used in America, and since that time I have continually studied to secure better results and have taken out 10 patents in all relating to the subject and have carefully observed the operation of my various plants and experiments to secure greater practical efficiency in clarification, sterility and dispersion. These are copies of the various patents (producing papers).

Q. What personal knowledge have you of conditions in the Passaic River and the Passaic Valley?

Mr. Riker: The question is objected to on the ground that it is irrelevant.

The Commissioner: Note the objection of Counsel for Defendants.

The Witness: I have personal general knowledge of the conditions in the Passaic River and Valley, having interested myself therein at intervals for the past 15 years, more particularly during the past 7 years, and have written on the subject for the press and spoken at public hearings in an effort to induce the authorities to treat their sewage by precipitation and sludge removal, being actuated thereto by my speciality interest and also by my interest as a citizen and sanitarian to prevent what I believe to be an error of judgment and which I also believe to be a practical retrogression in sanitation. To select the Harbor of New York for further experiment in an effort to render sewage innocuous by dilution seems a great error, when the resultant effect, if unfavorable, will seriously im-
3880 pair the hygienic, piscatorial and navigable advantages of a great harbor. It is perfectly practicable to conduct the necessary experiments in Newark Bay, at much less expense and less injury to navigation and hygienic offense.

Q. Have you made any special study of the meteorological data referring to the Upper New York Bay?

Mr. Riker: The question is objected to inasmuch as it is not directed to the rebuttal of any testimony given on behalf of the defendants.

The Commissioner: Note the objection of Counsel for the Defendants.

The Witness: Yes. I have obtained from the United States Department of Agriculture, Weather Bureau, in New York, their data, the Annual Meteorological Summary of 1911 and 1912, with comparative data published by authority of Willis L. Moore, Chief, United States Weather Bureau, and compiled under the direction of James H. Starr, and from that data on page 11, I have prepared a chart indicating wind directions as given in the Meteorological Reports which I now offer.

Q. Taking the data from the source that you have just described, have you caused the subject matter in these reports to be plotted or graphically set forth on any map?

A. I have.

Q. On what map?

A. On the Hydrographic Chart of New York Harbor.

Q. Where did you get that Hydrographic Chart?

A. From the Hydrographic Bureau of the United States through the Custom House in the City of New York.

Q. And what is shown on that map in addition to the matters that were on it when your received the map?

3881 Mr. Riker: Same objection to that question as to the last question.

The Witness: There are arrows indicating the wind directions as described in the Report of the Meteorological Bureau, and also a legend stating what was done.

Q. Who prepared those additions to that map?
A. I did.

Mr. O'Sullivan: I offer the map described by this witness in evidence and ask that it be marked Complainants' Exhibit No. L98.

Cross-examination by Mr. Riker:

Q. Did you have any part, Mr. Powers, in getting the data, upon which you say this map was prepared?
A. Do I understand obtaining the data of the chart itself?

Mr. Riker: Will you read that question?
(The question was read by the stenographer)
The Witness: Why, yes.

Q. What part?
A. I obtained the report of the Meteorological Bureau and obtained the maps and studied them.

Mr. Riker: Read that question again. I would like you to answer the question, Mr. Powers.
The Witness: I will try to if I understand it.
(The question was again read by the stenographer)
The Witness: Yes, sir.

Q. Anything else except what you have described?
A. No, sir.
Q. You call that getting the data, do you, getting it from somebody else?
A. The data that I wished to place on it, which I wished to present.
Q. You understand the data to be that pamphlet, do you?
A. I understand the data to be the arrows and wind directions that I have put on the map which were copied from this data.

Q. Well, did you have anything to do with obtaining the
3882 facts which you have used as the data for the preparation of this map?

A. No.
Q. Now, what part did you have in the making of the map itself?
A. Marking of the map itself?
Q. As presented, yes, sir?
A. As presented?
Q. Surely?
A. The placing of the arrows and the legend on it.
Q. You did that yourself?
A. I placed them on and my assistant copied them in under my direction, in my presence.
Q. Well, if he placed them on, how did it happen he copied them in?

A. I placed them on in lead pencil and he copied them in ink.
Q. He inked them in?
A. Yes, sir.
Q. Did you see him do it?
A. Yes, sir.

Mr. Riker: The map is objected to on the ground that it does not contain any original material within the knowledge of this witness; on the further ground that it is not rebuttal of any testimony offered on behalf of the Defendants.

The Commissioner: Note the objection of Counsel for Defendants.

The map was received in evidence and marked Complainant's Exhibit No. 198.

Direct examination by Mr. O'Sullivan (resumed):

Q. Will you describe, Mr. Powers what these arrows and this legend mean or signify?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

The Witness: On page 11 of the Annual Meteorological Summary——

Q. For what year?

A. For 1912. The second table, the heading, reads as
3883 follows: "Wind direction. Monthly and Annual percentage found (Period 1894-1903 inclusive)". That table gives by percentage the prevailing winds during the several months during that time. I have indicated from that table on here (indicating) by arrows the direction of those winds.

Q. And what color are those arrows?
A. Red.
Q. Have you placed the percentage of prevailing winds there in connection with these arrows?
A. I have, yes, sir.
Q. Are you familiar with the conditions in Boston Harbor and in New York Upper Bay?
A. I am.
Q. Will you compare these conditions?

Mr. Riker: The question is objected to.

Q. On the question of dilution particularly?

Mr. Riker: The question is objected to on the ground that it is not directed to any testimony given on behalf of the Defendants and it is not rebuttal.

The Commissioner: Note the objection of Counsel for Defendants.

The Witness: The Harbor of Boston, which has a dilution content of 279 cubic feet per 1,000 of population, is unsatisfactory. That I have taken from the Report of the Massachusetts State Board of Health——

Q. For what year?

A. 1900, pages 512, 70, and 71. Page 5: (reading) "At the outlet near Deer Island Beacon, which is four and two thirds miles from Long Wharf, in Boston, and in the northerly edge of the Main Ship Channel, sewage from the North Metropolitan District is allowed to discharge as it comes at all stages of the tide. The quantity of sewage discharged in 24 hours now reaches about
3884 50,000,000 gals., and this quantity, while distinctly visible along the northerly edge of the Channel for a half a mile towards the City on the incoming tide and towards the sea on the outgoing tide, gradually becomes less distinct at greater distances."

Mr. Riker: One moment. Now, I object to the Witness' reading from this report without its being proved. If the report is admissable, it should be offered.

The Commissioner: Note the objection of Counsel for Defendants.

The Witness: Page 12: "At a time when the average quantity of sewage flowing from the outlet amounted to about 42,000,000 gallons a day, showed us that sewage could be traced for a distance of only about a mile from the outlet on the incoming tide, and for about one and one eighth miles from the outlet on the outgoing tide, and these results have been confirmed by further investigations made recently by the State Board of Health."

Page 70: "The mingling of the sewage with the water takes place all over the area covered by the sewage, but goes on more rapidly near the edges of the area than elsewhere. The sewage remains quite close to the surface of the water, which is covered for a time with a greasy film. This film appears to be very thin and sometimes extends considerably beyond the area otherwise affected by the sewage. It is apparently composed of grease or oil from the sewage, and it is most noticeable on calm days. The observations indicate that, the greater the quantity of sewage that is discharged from the reservoir, the greater will be the area of the harbor that will be covered with sewage and the area covered will ap-
3885 parently increase in more than direct proportion to the quantity of sewage discharged. It is not likely that any considerable proportion of the sewage would pass out the harbor north of Long Island."

Page 71: (Same Report) "With the present quantity, the sewage has been found to be recognizable for nearly two hours and a half after the discharge at the outlet has ceased."

Q. Now, what would be the dilution in New York Harbor and will you compare these two sets of conditions in Boston Harbor and in New York Upper Bay.

Mr. Riker: The question is objected to on the same grounds as those urged on the last question.

The Commissioner: Note the objection of Counsel for Defendants.

The Witness: The Harbor of Boston has a dilution content of

279 cubic feet per 1,000 of population. In New York Harbor it has only 72 cubic feet dilution per 1,000 of population, or less than one-fourth the dilution in Boston Harbor.

Q. What do you infer from that condition?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

The Witness: That if they cannot produce a satisfactory result in Boston Harbor with a dilution of 279 cubic feet per 1,000 of population they certainly cannot get a satisfactory inoffensive result in New York Harbor with a dilution of 72 cubic feet per 1,000 of population.

Q. Have you devoted any attention to the self-purification of waters?

3886 Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. I have. Streams that a few years ago were certified to as having capacity of self-purification are to-day putrid channels of filthy water and their beds reservoirs of putrid slimy deposit.

Q. How does that apply to New York Harbor?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

The Witness: The only way this result can be prevented in New York Harbor is by causing the precipitation, coagulation and chemical combinations that result from admixture of sewage with salt water to occur in the deposition tanks at the Newark sewage treatment works, or in Newark Bay, and provide as far as possible against secondary reactions that induce injurious combinations. It has been found in practice that the per capita dilution that was supposed to dilute sewage to inoffensiveness is today inadequate and even an amount of dilution one hundred times greater is totally incapable of depriving sewage of its offensive character; and as a matter of fact there can really be no dilution of sewage solids until they have decomposed, then the gaseous products of their decomposition will be absorbed by the diluent and the result will be a stinking diluent. The present condition of the Passaic River shows putrescibility of its contents for the entire length, and this result has occur-ed within twenty-five years. I judged there that this result has occur-ed within 25 years and to verify that I quote from Slater Sewage Treatment Purification and Utilization in a statement made by Professor A. R. Leeds, Ph. D. where he says: "In proof of the efficacy"——

3887 Mr. Riker: Now, I object to the use of this matter as not being properly proved in any way, not being evidence and not being rebuttal of anything in Defendants' testimny.
The Commissioner: Note the objection of Counsel for the Defendants.

The Witness: "In proof of the efficacy of these natural agencies,

he refers to the River Passaic pure above the Town of Paterson, but polluted by the sewage and the manufacturing refuse of that town, he writes:—'The river immediately below the town is black with dye-wares, the fish carried over the Great Falls are immediately poisoned, and I have seen the foul smelling and disgusting water covered with their floating carcas-es.' Yet samples of water taken at intervals of a mile apart down the river show a regular decrease in the organic pollution, and an improvement in the quality, until at a point 16 miles below Paterson, the river has returned to a condition of purity not much inferior to that which it exhibited above Paterson, and at this point it is used as a water supply for the 300,000 inhabitants of Jersey City and Newark."

Q. What year was that published, that book?

A. 1888.

Q. Have you given the full title of the book?

A. Yes.

Q. I hand you Mr. Powers, Defendants' Exhibit No. 5 (handing witness paper) and ask if you have studied the effluent that is proposed in that exhibit to be discharged in New York Harbor at Robbins Reef, and if so, with what result?

A. Yes, I have. It is proposed in this exhibit to discharge
3888 an effluent into the Harbor of New York at Robbins Reef that has passed through grit chambers where heavy matters may deposit, if they will, then screened through a series of screens. First coarse screens placed in the flow to arrest the coarse matter and then pumped into a screen with mesh openings of 4/10-inch, through which it passes into tanks, where it deposits any sediment that will deposit during a flow of 15 feet per minute through the tank. In practical operation as a matter of fact the sewage will arrive at the sewer works after a flow of many miles. A large percentage of it has already been pumped. The whole has had the friction, attrition and resistance incident to such flow, the result being, of course, that all the feces will be broken up into small particles, all of which will readily pass through screens of 4/10-inch mesh.

The rags, paper, pieces of soap, vegetable refuse and solidified grease having more resistance to separation will be arrested in the screens, provided it is found possible to operate them. In practical operation there will be tons of lint, shreds of fibre from the silk, cloth-finishing, dyeing and leather works and the laundry operations incident to a population of 734,396 persons in the district which this sewer will serve.

Q. Now, based on your practical experience what do you infer from that?

A. Based on my own practical experience in screening sewage during the past 40 years—is that the screens will foul so rapidly that they will have to be dispersed with and that all the excreta will pass through the screens.

If there is no provision made for precipitation or disinfec-
3889 tion, the settling tanks will contain all the feces and grease in an advanced state of offensive decomposition, part of it

floating and part on the bottom, and the intervening depth of semi-fluid filled with flocculent matter in a transition state, alternately falling and rising as they become gaseous.

A large part of the contents will be a slimy, mucilaginous mass of partly dissolved feces, grease, and pulpy residuum that certainly should have some treatment, either filtration, precipitation, or admixture, to make the fluid portion fit for discharging into the outlet sewer.

Q. Now, will you extend your experience to the drawing off of the effluent from these settling tanks?

A. Well, based on my own experience in drawing off the effluent from settling tanks in several large plants that I installed and observed, if it gets no further treatment before discharge, the greater part of the flocculent matter will be discharged with the effluent.

Q. I hand you Complainants' Exhibit No. 135, Mr. Powers, and ask you if you have studied that exhibit?

A. I have, sir; I have seen a copy of this.

Q. You have had a copy of it and studied it?

A. I have had a copy of it and studied it.

Q. Can the results stipulated for in that exhibit be produced by the plant described therein?

Mr. Riker: The question is objected to on the ground that this exhibit was under direct examination in Complainants' direct case and has been the subject of a number of witnesses' opinions and that this evidence that is sought from this witness is not rebuttal
3890 of anything that has been adduced in Defendants' case.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: Complainants' Counsel presses this line of inquiry because this particular exhibit was discussed by a witness produced by the defense, Mr. George A. Johnson. Read the question.

(The stenographer thereupon read the question.)

The Witness: No, without treatment of the effluent it will be impossible to comply with the stipulation, that is stipulation No. 135 entered into with the United States, because in silk throwing and silk dyeing there is used in the City of Paterson alone more than seven million pounds of soap. A large percentage of this is not recovered and the Hazen report states on page 17, Appendix I, paragraph 2, that this amount of soap solution must discharge into the sewer as it is too impure to put into the river. While this solution is not objectionable in the sewer, it is highly so in the harbor. The addition of salt or its discharge into salt water will result in the formation of soap granules and an insoluble calcium stearate which will color the salt water into which it is discharged and create a floating scum.

Q. How would the maceration of these solids and then forcing them through a 4/10th-inch mesh affect the sewage to be treated and the resultant effluent.

Mr. Riker: The question is objected to as not being rebuttal and

not directed to any specific part of the testimony of the defendants.

3891 The Commissioner: Note the objection.

The Witness. To macerate these solids by forcing them through 4/10-inch mesh screens and form a jelly that in no way changes the harmful nature of the solids and causes more rapid consumption of oxygen at the discharge point has no value. The solids should be removed in the works on the Newark Meadows, the soap liquid coagulated, and all this matter precipitated before discharge of the effluent, so that a great nuisance shall not be inflicted on a neighboring state.

Extensions of this nuisance from Newark Bay to Robbins Reef will have no remedial value. The problem should be solved at the place where the nuisance is created and not shifted into an adjoining state for solution.

Q. Where do you expect the effluent to be discharged, Mr. Powers?

A. At Robbins Reef.

Mr. Riker: Do you know that is in New Jersey?

The Witness: Yes, sir.

Q. Do you understand that the effluent is to be discharged into the Main Ship Channel in New York Upper Bay?

A. Yes.

Q. And with sufficient force to carry it across the current of the Main Ship Channel?

A. Yes, I understand that is provided for in the specifications.

Q. And that the boundary line of the states is in that Main Ship Channel?

A. I do.

Q. You mentioned something about precipitation. How long has that necessity for precipitation been recognized, Mr. Powers?

A. The necessity for precipitation has been recognized since

3892 1763, at which time it was first proposed by De Boissieu.

About 1780, and since that time, the treatment of sewage to prevent the discharge of solids into streams and bays has been generally recognized and recommended in almost every case where sewage disposal has been considered. Eminent men, all of whom had given much study to the question, have invariably recommended treatment of the sewage effluent by some method before discharge. The few who in previous years recommended dilution without treatment have had ample opportunity in recent years to observe the effect of their errors and the injury and nuisance that has resulted from reliance on dilution without removal of the solids. Where eminent men have stated that sewage could be digested in water by dilutions varying from 3 to 20 they of course have assumed that the sewage supply would not be continuous and that additional sewage would not be added during the distance of the flow that they prescribe, and when additional quantities have been added during the length of said flow, of course the primary requirements would be violated and the necessity created for further dilution and longer flow. For example: if sewage is discharged into a stream

or bay and after flowing for 3 or 4 miles that additional sewage should be added, the effect would be to nullify the digestive operations which the primary discharge was undergoing.

During recent years the increased pollution of streams has attracted greater attention from the governing bodies and the scientists because of the monetary damages for riparian rights injured, fishery interests destroyed, and the nuisances created by emanations from the putrefying mass.

3893 As an example of the impossibility of the dilution of solids, I wish to state that sanitary authorities generally require that water-closets shall be flushed from individual tanks having a capacity of from 7 and a half to 10 gallons; and this quantity is discharged with each use of the closet; as the amount of dejecta in such use is but one-sixth of a pound and it is discharged into and with 62 and a half pounds of water the dilution at the time of use alone is 372 to 1. As the sewage discharge of residential and manufacturing places is generally 100 or more gallons per head of population and the fecal discharge is one-sixth of a pound, there is a further dilution of 833 pounds of water to one-sixth pound of fecal matter, or a dilution of 5000 to 1. If it were possible to dilute solids this amount of water dilution would certainly dispose of them, but as they are not soluble until after they have putrefied or been macerated, it follows that you cannot dilute this matter while in a fresh condition, and they should be separated from the fluids so that their progressive decomposition and the resultant gases therefrom, which are soluble, may not impregnate the fluid. In my opinion this separation cannot be affected by screening, because these matters and also the grease, while they may have a form, have very little cohesion, and any mechanical manipulation of them readily tends to break them up. The settlement is best effected by sedimentation, but precipitants and inertia are absolutely necessary to obtain a satisfactory result. Standard authorities give 25 tons of feces and 45 tons of urine per 1,000 of population. As the population in the sewerage district—as given in the Passaic Valley Sewerage Commissioners' Report of 1908, page 8, is

3894 702,000 persons in 1911, and the estimated increase about 31 per cent., I have taken 744,000 persons in the district at the present time as a basis of estimate. From the above number of persons the discharge of feces would be 18,600 tons per year and 282,720 tons of urine per year, or 1,500 tons of feces per month and 2,790 tons of urine per month, or 51.66 tons of feces and 93 tons of urine per day, which would be carried to the works on Newark Meadows, mixed with 75,000,000 gallons of water, allowing 100 gallons per head of population per day. There would also be contained in the sewage water many thousand pounds of soap liquid.

Q. Any trade wastes?

A. Well, I include in trade wastes everything that is for manufacturing interests in my view of it. It would appear that in addition to the soap solution from laundry and domestic wastes, from the large silk treatment works, and from the small silk throwing,

cloth and other manufacturing intetrests that use soap, there would be in solution in the daily discharge many tons of soap.

This enormous amount of soap solution would seriously affect the provision in the stipulation of the Passaic Valley Sewerage Commission with the United States, wherein the Passaic Valley Sewerage Commission has agreed that the effluent discharged by them at Robbins Reef will create no discoloration of the waters of the harbor. It is impossible to discharge this amount of soap solution into salt water without creating soap granules and scum upon the surface; the mere admixture of the soap solution with the salt water produces coagulation and an insoluble calcium stearate, which will spread out on the sufrace of the harbor and certainly create discolloration.

Now, in verification of that, I would like to refer to Report on
3895 Sewage Disposal of the City of Paterson, June 30th, 1906.

The following is from page 93, paragraph 5, Report on Sewage Disposal of Paterson, New Jersey: "It must be admitted that New York is better off without the discharge of New Jersey's sewage. The discharge of sewage will tend to pollute the Bay locally. There will be an appearance of sewage for some distance around the proposed outlet, and this outlet is near the Main Channel of the Harbor. There will be some odor and grease, for the sewage will smooth the waves and show its presence over a considerable area."

Q. Now what benefit would you expect to flow from carrying this effluent from the sewage disposal works on the Newark Meadows to Robbins Reef for the discharge?

Mr. Riker: It is objected to on the ground that it is not rebuttal of any evidence offered in behalf of the Defendants.

The Commissioner: Note the objection.

The Witness: There is no benefit that can result from carrying the effluent through the tunnel. There is no additional treatment admixture with any agent or sedimentation that could in any way improve the effluent from the time it leaves the Newark Meadows works until it is discharged at Robbins Reef. If this effluent, when it issues from the works on Newark Meadows, is an inoffensive clarified effluent incapable of offense, why is it necessary to spend several million dollars in conveying it several miles to Robbins Reef? If it is inoffensive, there is no objection whatever to discharging it into Newark Bay; in fact if it is a well clarified effluent it will improve the condition of the bay. There will be a
3896 great saving of money if the tunnel to Robbins Reef is omitted until such time as by experimentation in the actual operation of the works it shall have been demonstrated that there is either no objection or no necessity for continuing to Robbins Reef.

This omission of the tunnel to New York Bay was suggested by Hon. Andrew F. McBride on page 7 of his special message to the Municipal Boards of the City of Paterson in 1910.

Q. Have you got a copy of that message?

A. I have, (producing paper).

Q. How did you get this copy of the Special Message of Mayor Andrew F. McBride?

A. I asked him for one before it was printed and he said that he would mail me one as soon as it was printed and did so.

Q. Was his signature attached to it?

... Yes, sir.

Mr. O'Sullivan: I offer that in evidence and I ask that it be marked Complainants' Exhibit No. 199.

Mr. Riker: The offer is objected to on the ground that it is irrelevant, incompetent and immaterial.

Received in evidence and marked Complainants' Exhibit No. 199.

Q. What special portion of Complainants' Exhibit No. 199 did you wish attention to be directed to in support of the statement that you have just made previously, Mr. Powers?

Mr. Riker: The question is objected to on the ground that it deals with a matter not even touched in Defendants' evidence and is not rebuttal.

The Commissioner: Note the objection.

Mr. O'Sullivan: Complainants' Counsel presses this *this*
3897 line of inquiry in line with that provision of the Laws of the State of New Jersey for the year 1907, being Chapter 10 of the Laws of 1907, the 9th section of that law providing in its last paragraph for the taking over by the Passaic Valley Sewerage Commissioners of all plans, maps, data and reports which it may have produced, purchased or secured relating to those secured, purchased and produced by the City of Paterson, and in which there is provision for compensation also to the City of Paterson. This being one of the special messages, forms a part of the records of the Passaic Valley Sewerage Commission. Read my question to the witness.

(The stenographer thereupon read the question.)

The Witness: 5th paragraph, page 7. Shall I read it?

Q. Yes.

A. (Reading:) "The main question of disposal of the sewage has not been decided. If a trunk sewer can be built for the money reported by the Sewerage Commission and permission can be had to empty the same into New York Bay without purification works, then Paterson should join in the plan. If the sewage must be purified, as we have every reason to believe, then there is no reason for extending the sewer to New York Bay. The great expense of a tunnel to New York Bay should be avoided and the purification works built on Newark Meadows."

Q. An effluent such as you state would be likely to be produced by the plan described in Complainants' Exhibit No. 135, how would you expect such an effluent to affect the navigability of New York Upper Bay and the Harbor of New York.

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence offered on the part of the defendants and further because it deals with a matter exclusively within the

jurisdiction of the War Department of the United States
3898 Government, who are not concerned in this suit.

The Commissioner: Note the objection.

The Witness: Read that question again, please.

(The stenographer thereupon read the question.)

The Witness: Well, this would be the effluent there—it would simply affect the appearance of it and to injuriously affect the appearance or salubrity, or impair the navigability of the Harbor of New York, would give offense to the Merchant Marine of the world who all navigate these waters.

Q. Are you familiar with the conditions in the Chicago Drainage Canal?

Mr. Riker: The question is objected to as immaterial and irrelevant; not rebuttal of any evidence offered on the part of the Defendants.

The Commissioner: Note the objection.

The Witness: I have examined the report and read considerable regarding it, and I understand that the Chicago Canal Commissioners had applied to the Hon. Henry L. Stimson, Secretary of War, for 200 per cent. more water than they originally were allowed and that that was denied.

Q. Well, before we go to that, Mr. Powers: what occurs when streams of fresh water discharge into salt water—the fresh water streams being polluted?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

The Witness: Many things occur; but it is a matter of general knowledge that streams of fresh water discharging into salt, do not enter into combination at once, but must flow for long distances to obtain the necessary agitation that causes them to combine
3899 and that during that flow they are recognizable by color.

Q. Would you expect that to occur in the proposed discharge at Robbins Reef?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

The Witness: In the proposed sewage discharge at Robbins Reef there will be a conspicuous bubbling over the dispersion area and that there will be an offensive odor from the discharge also scum at this point and the surrounding area.

Q. Why?

A. Well, because there has been no antiseptic treatment of the effluent discharged, and of course in its passage along the several miles of tunnel, it will be undergoing fermentation and putrefaction, and when discharged, why, of course, it will have smell and color both. To discharge this amount of sewage into New York Bay without purification or clarification enough to render it innocuous before discharge, would be, in my opinion, a violation of

decency and sanitation, and unjust to the accumulated knowledge on this subject in this age.

Q. Now, have you read some of the testimony given by the witnesses for the defense in this suit?

A. Some.

Q. From your study and knowledge of the conditions and of the exhibits submitted to you, what in your opinion will result from the discharge of the effluent described as being produced by the plant outlined in Complainants' Exhibit No. 135?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

Mr. Riker: Further that the witness' attention should be drawn, that counsel may understand what he is testifying to, to
3900 the specific parts of the testimony which are sought to be rebutted and which has not been done in this case.

The Witness: Read the question, please.

(The question was read by the stenographer.)

The Witness: In that exhibit No. 135, no provision is made for precipitation by the admixture of any agent or filtration or anything that would tend to remove the flocculent matter from out of the effluent, and in my opinion there would be a discoloration and offense at all times at the point of discharge at Robbins Reef.

Q. Directing your attention again, Mr. Powers to Complainants' Exhibit No. 135, will the plant described in that exhibit produce an effluent which if discharged at Robbins Reef, will or will not occasion a nuisance?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

The Witness: I believe it will occasion a nuisance. I would like to say right there, that, there being no necessity for taking chances of creating a nuisance and as they have such a splendid opportunity to treat that sewage in some way on Newark Meadows that would be inoffensive, that I believe it should *ne* done. Now, I have calculated the dilution by gallons in Boston Harbor, New York Harbor, the Chicago Drainage Canal at a dilution of 6 cubic feet per second flow. The Boston Harbor dilution contents is 279 cubic feet per second from 1,000 of population. 279 cubic feet per second is 2092 gallons and is 125,520 gallons — minute, or 7,531,200 per hour, and is 180,748,800 gallons in 24 hours. New York Harbor has 72 cubic feet per second for each 1,000 of population. 72 cubic feet per second is, 540 gallons per
3901 second, is 32,400 gallons per minute, is 1,944,000 gallons per hour, is 46,656,000 gallons per 24 hours, is 46,656 gallons of water for each person.

Q. What is the ratio of dilution in Chicago, the Chicago Drainage Canal?

A. The Chicago Drainage Canal has 1,000 cubic feet per second—asks for 1,000 cubic feet per second for each 300,000 of population.

The reason that they ask for that is stated in page 193 Appendix No. 2 of Lake Diversion at Chicago.

Q. By whom?

A. By Lyman E. Cooley.

Q. For what year?

A. 1913, February. He states therein on page 193: "The least amount of water necessary to render sewage innocuous by the dilution method has been estimated by well recognized sanitary experts as 1,000 feet per second.

Q. Cubic?

A. Cubic feet per second for every 300,000 inhabitants.

Q. Have you made any calculations on that?

A. I have. 1,000 cubic feet per second is 7,500 gallons per second, is 450,000 gallons per minutes is, 27,000,000 gallons per hour is 648,000,000 gallons in 24 hours,—2160 gallons per day for each person would amount to 648,000,000 in 24 hours.

Q. Have you made a calculation on dilution at 6 cubic feet per second?

—. I have, sir, by gallons, 6 cubic feet per second, 45 gallons per second, 2,700 gallons per minute, 162,000 gallons per hour, 3,888,000 gallons per 24 hours.

Q. Is that for each person?

A. No, that is for each 1,000 persons.

Q. For each 1,000 persons?

A. Yes.

Q. In relation to the map which you have prepared and admitted in evidence as Complainants' Exhibit No. 198, where would you expect depositions to occur from this effluent proposed to be
3902 discharged under Complainants' Exhibit No. 135?

Mr. Riker: Same objection; not being rebuttal.

The Commissioner: Note the objection.

The Witness: Well, that would depend on the direction of the wind. The various winds—several winds would carry the lighter particles to the—this being Robbins Reef at the point of discharge, a west wind would blow it towards Brooklyn, that is, Bay Ridge. The northwest wind would blow it in the same direction; a north wind would blow it towards the shores of Staten Island. Northeast wind would blow it towards the shores of Staten Island. A southwest wind would blow it up towards New York City.

Q. Meaning what?

A. Manhattan Island, and Governors Island and a northwest wind would also tend to blow it ashore at Fort Hamilton. Now, the drift of scum from my own personal knowledge—I speak now of scum, not of deposited solids—at this point here in Gravesend Bay, in the bight of Gravesend Bay, on the Coney Island Shore, there is generally a deposit of floating sea weed and so on. To my own knowledge, there are men there who make a business of collecting that sea weed and furnishing it to the Aquarium for use.

Q. Have you had any direct personal experience with floating

matters that were blown on to the Brooklyn shores causing infection of any kind.

Mr. Riker: Same objection.

The Commissioner: Note the objection.

The Witness: Well, I have had no personal experience, but it is stated in the Medical Report, of the yellow fever of 1856,
3903 that the infection at Bay Ridge was from vessels anchored at Quarantine, and that all the cases of yellow fever that occurred there were within 50 or 60 yards of the Beach. Of course, I have no personal knowledge of that. That is in 1856.

Mr. O'Sullivan: He is your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. Well, Mr. Powers, you have characterized with some adjectives, the proposed discharge of an effluent from the Sewage Disposal Works of the Passaic Valley Sewerage Commissioners into New York Bay at Robbins Reef. What adjectives would you use for the discharge of crude sewage by the City of New York directly into the waters of New York Bay?

A. It is perfectly inexcusable in this age.

Q. Do you recall the adjectives you used with reference to the New Jersey discharge?

A. I do not.

Q. Would you apply the same or stronger ones to the discharge of crude sewage by New York City in the water of New York Bay?

A. I would.

Q. How far from the line dividing the State of New York and the State of New Jersey is the nearest outlet proposed for the Passaic Valley Sewer?

A. Well, no, I did not measure that and could not state it for a fact at all.

Q. Well, when you say the sewage is to be discharged across the Channel into New York Bay, or into the territory of New York, can you tell whether that will be so or not, without knowing the distance?

A. That is a statement in the Passaic Valley Sewerage Commission's Report for 1908 in the plan.

Q. Will you point it out?

A. Yes, sir; on page 21 of the Passaic Valley Sewerage Commission's Report (indicating.)

3904 Mr. O'Sullivan: Of what year?

The Witness: 1908, fourth paragraph, page 21. (Reading): "At a point in the rock north of the lighthouse the single sewer will be extended by a number of smaller outlet pipes at right angles to the current of sea water, so as to get the greatest possible dispersion over a large area."

Q. Yes, you interpret that to mean that it will discharge across the line, do you, into the territory of New York?

A. No, no.

Q. Isn't that what you say?

A. No.

Q. You didn't intend to say that?

A. No, sir.

Q. You simply intended to say that the direction is across the Channel as it states there (indicating)?

A. As it states there (indicating): I don't dispute that.

Q. Do you mean to say that discharge will carry the sewage directly across the Channel for a distance of a quarter of a mile?

A. It will depend, of course, upon the inflowing and outflowing tides; the currents and the deflections that it meets.

Q. I want to know whether in your opinion the discharge, as a distinguishable discharge, from the outlet to the Passaic Sewer in your judgment will carry a distance of a quarter of a mile through the waters of New York Bay?

A. I believe it will.

Q. You think that there will be a well defined stream of sewage, which will extend across the Channel of the Main Ship Canal for a distance of a quarter of a mile, do you?

A. I do.

Q. Have you ever seen any such thing happen?

A. Yes.

Q. Where?

A. At Coney Island. In 1896 we carried the force main discharge outlet down to the foot of 23rd Street and discharged
3905 at that point, and the well defined trail of it was seen out through there.

Q. Well, a well defined trail, what do you mean by that?

A. Well, a path, if you choose.

Q. On the surface?

A. Well, that is, of course, only the surface was visible and you could not see below.

Q. How deep do you understand the discharge outlets of the Passaic Valley Sewer are to be?

A. 40 feet below low water.

Q. And in your opinion there is enough hydraulic pressure on that outlet line to force the sewage at right angles across the Channel into the waters of New York Bay?

A. There is—it would be more in the dispersion there. There would be, as I understand it, about 12 to 15 feet hydraulic head on the discharge, but as it flowed up and on the current, it would go where the current was going.

Q. So that, after all, what you mean, is that in your opinion, these sewage matters will finally disperse so it will reach New York waters?

A. Yes, sir.

Q. And that is all you mean?

A. Yes, sir.

Q. What was the date of the report on sewage in Paterson that you read?

A. That was the Passaic Valley—no, the Report on Sewage Disposal of Paterson, New Jersey, 1906.

Q. Will you turn to the stipulation which is Exhibit No. 135 for the Complainants, and see what the date of that is?

A. (Reading.) This is the 14th day of April 1910.

Q. In your opinion an effluent which will not in any way be objectionable in Newark Bay, will that same effluent be objectionable in New York Bay?

Mr. O'Sullivan: Read that please.

3906 (The stenographer thereupon read the question).

The Witness: I think that I understand the gentleman's question.

Q. Well, I think it is perfectly clear; I think you might understand it. If it is not, I will re-frame it.

A. If the effluent is unobjectionable in Newark Bay, it would certainly not be in New York Bay.

Q. Don't you understand that Newark Bay is part of New York Harbor?

A. I did not.

Q. You did not understand that. Well, from the point of view of an expert to the results in the water, what difference does it make, whether it costs the Passaic Valley Sewerage Commissioners more money or less in your opinion, so far as the results upon the health and the appearance of the water are concerned?

A. Read that question.

(The stenographer thereupon read the question).

The Witness: I don't see that it concerns an expert at all regarding the expense.

Q. Well, what have you got to do with the question of whether it costs money or not, to run a tunnel out into New York Bay—as an expert?

A. Oh, as an expert?

Q. Yes.

A. Why, I believe that with the treatment that is described in Exhibit No. 135, that that effluent will be a nuisance in New York Bay, and I would be very much opposed to having it go there. If it was thoroughly clarified, of course, there would be no objection and I would have none.

Q. Yes, but what have you got to do as an expert with the cost of the outfall alone in New York Harbor or New York Bay?

A. I am a resident of the State of New Jersey.

3907 Q. Yes?

A. My family own property there and I would have the same interests that any other citizen would have, that is, in obtaining as good results as possible at the least expenditure possible to obtain.

Q. Have you got any property in the Passaic Valley Sewerage District?

A. In the Passaic Valley Sewerage District?

Q. In the Passaic Valley Sewerage District?

A. In the district?

Q. Yes, sir; I said the Passaic Valley Sewerage District?

A. No, sir.

Q. Well, how does it concern you what the district spends?

A. I don't see that it does.

Q. Now, Mr. Powers, assuming that the effluent produced and discharged by the Passaic Valley Sewer System is of the character which is specified in the second general paragraph of Complainants' Exhibit No. 135, are you still of the opinion that there will be a nuisance created in New York Bay by the discharge of that sewage?

A. Let me have that question again, please?

(The stenographer thereupon read the question).

The Witness: If it was of this character——

Q. That is what I said?

A. There would be no objection.

Q. Then the difficulty with you is that you don't agree with Mr. Hering and Mr. Fuller and Mr. Harrison, who have signed Defendants' Exhibit No. 5, that the processes described in the first part of that stipulation would produce that effluent?

A. Yes, sir, I differ with them on that.

Q. You differ with them on that. Who is Mr. Rudolph Hering, did you ever hear of him?

A. Yes, sir, I have known him for about 30 years.

3908 Q. Yes, sir, what is his profession?

A. He is an engineer.

Q. What kind of engineer?

A. A very eminent one.

Q. In what line?

A. In hydraulic and sewerage works.

Q. And Mr. George W. Fuller, do you happen to know him?

A. I have met Mr. Fuller; he is a very eminent man.

Q. Yes, in what line?

A. In water supply and sewerage.

Q. Do you know Mr. Edlow W. Harrison?

A. I have not had the pleasure of Mr. Harrison's acquaintance personally.

Q. Do you know him?

A. I know of him.

Q. What is his reputation, if you know it?

A. I regarded him and heard him spoken of as a very eminent and accomplished gentleman.

Q. Then your difficulty is that you don't agree with these gentleman?

A. Don't agree with them.

Q. And therefore it is purely a question of difference of opinion, is it not?

A. Yes, sir.

Q. Now, you said that there was no necessity to take the chances by discharging this effluent into New York Bay. Why is there no necessity for that?

A. Because if it is unobjectionable, it might just as well be discharged into Newark Bay.

Q. Yes, but you have got a condition in there. You say there is no necessity; well, why is there no necessity?

A. There is no necessity if they complied with that stipulation.

Q. You wish to qualify it with that condition. I understood you to say there was no necessity of taking the chance?

A. Of taking the chance, yes.

Q. Yes. Now, why is there no necessity?

A. Because if it is an unobjectionable effluent, well clarified
3909 and odorless, there is no objection to discharging it into Newark Bay.

Q. Well, now, isn't it possible to produce such an effluent?

A. Yes, sir.

Q. As a mater of fact by introducing to this system some devices or processes which you have patented, the thing can be done, can't it?

A. All my patents have expired.

Q. Well, I say——

A. Some of the things—there are various ways that it could be done.

Q. It could be done in a number of different ways?

A. Yes.

Q. And then the effluent in your judgment could be safely discharged into Newark Bay?

A. Yes, sir, or into New York Bay.

Q. And there would be no necessity of discharging it into New York Bay. These methods and processes are feasible?

A. Yes, sir, but very expensive.

Q. Well, you would not advocate the continuous discharge of the sewage into the Passaic River, would you; you would not recommend that?

A. No, sir.

Q. Nor in its crude state into Newark Bay, you would not recommend that?

A. No, sir.

Q. Well, what would you do with it, then?

A. I would purify it so that there would be no objection to its discharge in either one.

Q. Without regard to expense?

A. Without regard to expense.

Q. Well, now, turn again to Complainants' Exhibit No. 135 to which your attention has been drawn, I read the second section to you in these words—that the Passaic Valley Sewerage Commissioners further agree with the United States that in the opera-
3910 tion of said sewer system at all times the following results shall be secured either through compliance with the requirements of the immediately preceeding paragraphs, or other requisite, lawful additional arrangement. Then, if those guaranteed results are obtained in either of those ways, in your judgment there will be no nuisance in New York Bay?

A. No, sir, not if that was complied with.

Redirect examination by Mr. O'Sullivan:

Q. Drawing your attention, Mr. Powers, to the latter sentence that has just been read to you (reading) "or other requisite, lawful additional arrangement", what do you understand by that?

Mr. Riker: Well now, I object to the question being put to this witness on the ground that the interpretation of a written instrument is with the Court and not with the witness.

Mr. O'Sullivan: The question is pressed for the reason that he has just answered a question in which my quotation has been embodied, and with a view to determining whether the witness fully apprehends the importance and value of the question put to him.

The Commissioner: Note the objection of Counsel for Defendants.

The Witness: I would understand from that that any further treatment required would have to be made regardless of the expense.

Q. And how with reference to the lawful character of these additional requisite arrangements?

A. Well, that, of course would be a legal question and I am not qualified—that is, as a lawyer. Of course, if it were possible to raise the money, that would be another thing.

3911 Q. In your answer to Mr. Riker, Mr. Powers, did you contemplate interpreting judicially the sentence that I have quoted to you in my question?

A. Judicially? No, sir.

Q. Directing your attention again to Complainants' Exhibit No. 135, I ask you as a sewage expert if the plant described in that stipulation will produce the effluent and the results guaranteed in that stipulation?

A. In my opinion it will not. The further treatment will be required.

Q. Would it be an expensive process that would produce such results as are stipulated for in Complainants' Exhibit No. 135?

A. Yes, sir.

Q. If the effluent stipulated for or the results guaranteed in the Complainants' Exhibit No. 125 were produced, would there be any objection to its discharge into Newark Bay?

A. None whatever. It would be a benefit to the Bay.

Q. You were asked if you knew Mr. Rudolph Hering and Mr. George W. Fuller, do you know whether they are now alive and in health?

A. I have not met Mr. Hering in many years, but I have met Mr. Fuller in other cases, within recent years.

Q. You were asked as to the hydraulic pressure probable in sending the effluent through this long tunnel from the Newark Meadows to Newark Bay and under the Bayonne Peninsula and to Robbins Reef. Are you familiar with pumping devices?

A. Yes, sir.

Q. What types of power pumps or pump would be necessary to send it that distance?

A. Well, it would be absolutely necessary to use centrifugal

pumps, because the quantity is so large that piston pumps would be out of all proportion; they would have to be built in batteries.

3912 Q. And would a very great degree of force be necessary to send that effluent that distance?

A. No, only the difference between the hydraulic mean; you see the tide level would be the same at Newark Bay or slightly different, about an hour at the point of discharge at Robbins Reef. Now, of course, the hydraulic piston which would cause the discharge or issuance of that at Robbins Reef would simply have the head above that level, which is shown here as No. 100, described as 37 feet above the invert of the sewer and as the sewer is 26 it would make about 11 feet above the surface level or the tide level.

Mr. O'Sullivan: That is all.

Adjourned to May 20, 1913 at 10:30 A. M.

3913 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, May 20th, 1913.

Before James D. Maher, Esq., Commissioner.

Appearances:

W. J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants.

Adrian S. Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

GEORGE A. SOPER, a witness in behalf of the Complainant, recalled, in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Dr. Soper, since you were on the witness stand, before, has the Commission, of which you are President continued its work of investigation and of suggesting remedies for the conditions to which you testified previously, and if so, state what work?

Mr. Riker: Now, I object to the question on the ground it is not rebuttal of any evidence offered on behalf of the defend-
3914 ant, the rebuttal being properly directed to the specific testimony of the defense, and not to the general line of the defense.

The Commissioner: Note the objection of Counsel for the defendant.

Mr. O'Sullivan: You may proceed, Doctor?

The Witness: It has. The Commission has been continually at work, especially in preparing preliminary plans and estimates for such works of main drainage and sewage disposal as its previous studies had indicated were necessary and sufficient for the protection of the Harbor. At the same time the Commission has been making some analytical experimental studies into various questions. A large part of the planning has been published in a series of preliminary reports, of which two or three have already been put in evidence, I think, by me. Underlying these plans and estimates, as announced, there is a large amount of engineering work. For example, in one of the four divisions into which the Commission has separated the City of New York for purposes of studying, there were eight or ten alternate projects of plans made, the object being to develop the one that was most suitable for the locality.

Upon the Commission arriving at an opinion that it had worked out a plan and arrived at an estimate of cost which was suitable for the situation studied, the Commission has issued a report on that plan. That report has been termed preliminary because until the Commission's work of making such plans and estimates as were required of it for the whole of New York, it would not be safe in the Commission's opinion to call any of its plans final. In
3915 short, it would be necessary, when plans were made for each one of the divisions, to coordinate those plans in a better way than would be possible as the work progressed. Proceeding in the manner that I have mentioned, the Commission has issued preliminary report No. 4 to cover the collection and disposal of the sewage of the upper East River, and Harlem Division. The date of that report was July, 1912, and I have a copy here which was certified by the executive secretary to the Mayor, James Matthews.

Mr. O'Sullivan: I offer that report in evidence and ask that it be marked Complainants' exhibit No. 200.

Mr. Riker: The offer is objected to on the ground that it is incompetent, immaterial and irrelevant and not properly proved.

The Commissioner: Note the objection of counsel for defendant.

Received in evidence and marked Complainant's Exhibit No. 200.

The Witness: I have here preliminary report No. 5, termed "Study of the collection and disposal of the sewage of the Richmond Division." It is dated September, 1912, and has been certified in the Mayor's office.

Mr. O'Sullivan: I offer that report in evidence and ask that it be marked Complainants' exhibit No. 201.

Mr. Riker: The same objection as to the last offer.

Received in evidence and marked Complainants' exhibit No. 201.

The Witness: I have here preliminary report No. 6, termed

"Study of the collection and disposal of the sewage of the
3916 lower Hudson, Lower East River, and the Bay Division.
It is dated February, 1913. It has been certified in the Mayor's office by the Mayor's executive secretary.

Mr. O'Sullivan: I offer that report in evidence, and ask that it be marked Complainants' exhibit No. 202.

Mr. Riker: Same objection as to the last exhibit.

Received in evidence and marked Complainants' exhibit No. 202.

The Witness: Each one of these preliminary reports contains the following statements on the title cover: "This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted." Before these reports have been issued, the officers of the City charged with the construction of the local sewers, chief engineers of the sewer bureaus specifically, have been invited to come to the Commission's office and criticise the work done and to offer the Commission the benefit of such practical suggestions for the improvement of these plans as they could make, it has been after receiving such criticism that the foregoing reports have been made.

When the Commission had arrived at an opinion as to the character of the works required for the lower Hudson, Lower East River, and Bay Division, it seemed desirable to obtain the best construction
which could be obtained, not only from city officers, but from
3917 noted experts in sewage disposal. In order to obtain the best
and most unprejudiced criticism, the Commission sent to England and obtained the services of two experts, one a chemist and one an engineer, and in preliminary report No. 7 are contained the reports, the critical reports of Messrs. Fowler and Watson, on the projects of the Metropolitan Sewerage Commission.

Q. Of New York?

A. Of New York, with special reference to the plans proposed for the Lower Hudson, also Lower East River and Bay Division. This report is dated February 1913. I have a copy here which has been certified at the Mayor's office by the executive secretary to the Mayor.

Mr. O'Sullivan: I offer that in evidence, and ask that it be marked Complainants' exhibit No. 203.

Mr. Riker: The offer is objected to on the ground that it is not rebuttal, it is immaterial, incompetent and irrelevant; the matter is hearsay, and that the report is not properly proved.

The Commissioner: Note the objection of Counsel for the defendant.

Received in evidence and marked Complainants' exhibit No. 203.

Q. By whom were these reports prepared, Doctor?

A. The reports of Fowler and Watson, you mean? Are those the reports which you refer to or the other?

Q. Those that I have just put in evidence now, Complainants'

exhibit- Nos. 200, 201, 202, 203. State how they were compiled, by whom?

A. Excepting Preliminary Report No. 7, which is No. 203 of the exhibits, the Preliminary Reports have been prepared by the Metropolitan Sewerage Commission of New York, the drafting of the report being done in the first instance by the President of the
3918 Commission.

Q. Who is the President of that Commission?

A. I am the President and Executive Member of the Commission, through whom all the scientific and technical work has been done. The draft so prepared has been transmitted to each member of the Commission, and after study on their part and discussion, the report has gone to revision and finally when satisfactory to all the members of the Commission, it has been printed. Preliminary Report No. 7, which is Complainants' exhibit No. 203, consists of two parts: The first part is a brief introduction to the second part; the first part, the introduction, was prepared as I have described for the other preliminary reports. The second part consists of two reports, one by Dr. Gilbert J. Fowler, of Manchester, England, and the other by Mr. John G. Watson, of Birmingham, England. The report of Gilbert J. Fowler was received by me as President of the Sewerage Commission. It was put into type under my immediate direction. The report of John G. Watson was received and printed under the same circumstances.

In preparing these reports, Messrs. Fowler and Watson were invited by the Sewerage Commission to come to New York and make such studies of the local situation as would enable them to teach from first-hand knowledge of the Conditions which could be observed. They came separately. Dr. Fowler arrived first and spent about two weeks in New York. When he arrived, he was expected to have a knowledge of the Commission's reports of data, and at the end of Dr. Fowler's visit Mr. Watson arrived. He made his studies, as Dr. Fowler had, and with a knowledge of the Commission's work as contained in reports. The studies on the ground were made separately by these experts, excepting for two or three days
3919 when their visits unexpectedly overlapped. Two months after the return of the experts to England, their reports were made.

Q. And are embodied in Complainants' exhibit No. 203?

A. And are contained in Complainants' Exhibit No. 203.

Q. Since you were on the stand last, Dr. Soper, has the Metropolitan Sewerage Commission continued analyses of the waters in order to determine whether or not material changes had taken place subsequent to the analytical surveys made in 1911 and to which you testified?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence introduced on behalf of the defendant-, and is immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for the defendant-.

The Witness: Yes.
Q. What analyses were made by the Commission?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

The Witness: Analyses reported in the large bound volume which the Commission issued in August 1912, report the analytical data collected to November 1911. From November 24, 1911, to April 5, 1913, the following analytical work has been performed: Dissolved oxygen in the Harbor water——

Mr. Riker: Well, one moment. I object to the testimony unless it appears that it has been done by this witness. It has not yet appeared. He says it has been done, I do not know whether he has done it or not.

3920 Q. Under whose direction, Dr. Soper, was this analytical work done?
A. Under my direction.

Mr. Riker: Is this responsive to any question?
Mr. O'Sullivan: I asked in relation to the analyses made by the Commission. Will you read my question?
The stenographer thereupon read the question.

Mr. Riker: That calls for yes or no.

Mr. O'Sullivan: Add to my question: "If so, state what analyses were made."
Mr. Riker: Additional objection is now made to the question as propounded that it calls for an answer within the knowledge of this witness, things that he has done himself.
The Commissioner: Note the objections of Counsel for the defendant.

The Witness: Dissolved oxygen in the Harbor water, 395 analyses; dissolved oxygen in incubated Harbor water, 219 analyses; salinometer tests with dissolved oxygen 395 analyses; tests for the best alkali to use for the dissolved oxygen analyses, 38; example experiments to determine whether sea water merely saturated with oxygen can be entirely saturated by shaking, four; dissolved oxygen in storm water, 1; cause of supersaturation of oxygen in water—this was an experiment dealing largely with the effect of temperature on saturation—20; rate of absorption of oxygen by water lying exposed to the air, 130; loss of oxygen in mixtures of sewage and sea water on standing for various periods of time, 24; effect of sludge on the amount of oxygen present in the overlying
3921 water, 7; loss of oxygen in unpolluted sea water on standing, 2; fermentation of Harbor water in Winter to determine whether fermentation takes place at ordinary water temperatures in the Winter season, 6;

Viability of bacteria in sewage and water, 80; viability of typhoid germs in water, 167 experiments; viability of typhoid in urine, 39; viability of typhoid in shellfish, notably oysters and clams, 93 tests;

uranine or tests of the movements of sewage—the tests carried on by means of dye called uranine 3; the total number of tests carried on in the group of researches just referred to was 1,613.

Passing now to another group—tests for albuminoid ammonia in the Harbor water, 200; tests for free ammonia in the Harbor water, 200; tests—and by tests I mean determinations of the amount of in all of these cases that I am now dealing with—nitrates, 223; tests of nitrites, 241; of salinity, 110; turbidity 80; color 110; dissolved oxygen 100. These tests mentioned in the last group have all been made on Harbor water.

Q. New York Harbor water?

A. New York Harbor water, soon after the samples were collected. There were determinations as follows for New York Harbor water after incubation:

Albuminoid ammonia, 152; free ammonia, 172; nitrates, 142; nitrites, 142; direct nesslerization of Harbor water, 10; determinations of dissolved oxygen in sewage 13; oxygen consumed in sewage 13; albuminoid ammonia in sewage, 13; nitrates in sewage 14; chlorine in sewage, 13; solids in sewage 26; determinations of numbers of bacteria in sea water, public water supply of New York, and Harbor water, 217; tests upon the putrification of sea water by coagulation——

3922 Q. Is that sea water or sewage, Doctor?

A. Sea water and sewage, mixtures of the two. In connection with these experiments that I now mention, I had to do with studies of the Commission into the possibilities of using sea water to purify sewage, the idea being that there was a great deal of salt of various kinds in the sea water which might perhaps be turned to advantage in purification of the sewage before the sewage should be discharged. It was noted that when ordinary toilet and other washing soaps were discharged into the sea water and mixtures thereof a coagulation occurred and it was thought perhaps that coagulation might be turned to advantage in some method for the economical treatment of the sewage of New York City. 46 experiments were made with soap and sewage and sea water. It was then considered that these studies should be carried on with some of the ingredients of the soap; 71 experiments were made in this direction. The Commission then undertook experiments on the treatment of sewage by the aid of mixtures of sea water treated electrolytically for decomposition of the salts in the sea water. There were 130 experiments of this kind. Tests were made for the amount of carbon dioxide, 302, in Harbor water; there were 10 of these tests. There were 20 tests for various gases, not only carbon dioxide, but other gases in the Harbor water, the method in this case being to boil out the gases from the water and to determine the gases quantitatively by volumetric methods.

Q. Will you name some of those gases besides the carbon-dioxide, Doctor?

3923 A. Oxygen was one, methane another, sulphuretted hydrogen, hydrogen and nitrogen were gases to which interest attached. Experiments to the number of tests were made upon the pos-

sibilities of using aluminium sulphate in the purification of the sewage. 30 determinations were made of the temperature of the sludge found on the Harbor bottom under different circumstances which occurred. There were 65 tests made to determine the rate at which sewage sludge absorbs oxygen from the Harbor water. There were 6 tests of the volume of gas found when sludge decomposes. There were 25 tests of the effect of bleaching powder as an oxidizing agent in treating the sewage. The effect of liquid chlorine as an oxidizing agent was examined in 40 experiments. There were 42 sets of samples of Harbor water to show the effect of freshet stages in the Hudson River, as far as those stages could affect the water in the East River, the belief being that Hudson River water flowed into the East River, and it being desired to ascertain some of the consequences. There were 40 tests made to show how sewage spreads out on the surface of the water of the upper East River, when discharged from the sewer outlets which there exist. The total number of tests referred to in this second group is 2,748.

The foregoing represents a brief outline of the analytical work, particularly the object and number of tests made since October and November, 1911.

Q. Has the Commission, the Metropolitan Sewerage Commission of New York, drawn any inferences from the data which you have just now testified to in relation to the assimulable qualities of the water of New York harbor for the digestion of sewage, and assimilation?

Mr. Riker: Same objection as to the preceding question.

The Commissioner: Note the objection of Counsel for the defendant.

The Witness: It has.

3924 Q. Will you state what those inferences are, Doctor, that have been drawn by the Commission, as to whether or not the waters have deteriorated or improved in that respect.

Mr. Riker: The question is objected to as not calling for any evidence on the part of this witness or even as to his own opinion, but to state the inferences of a body of which he is simply a member; and also on ground that it is incompetent irrelevant and immaterial, and not rebuttal of any testimony offered on behalf of the defendants.

The Commissioner: Note the objection of Counsel for the defendant.

Mr. O'Sullivan: You may proceed, Doctor.

The Witness: What is the question, please?

The stenographer thereupon read the question.

The Witness: The opinion of the Commission is that the waters have deteriorated. In some analyses of the water of the Lower East River for dissolved oxygen the Commission has found a smaller percentage of saturation than had formerly been observed. The average of a series of examinations indicated that the water of the Lower East River in the vicinity of the Brooklyn Bridge had fallen to 43 per cent of its saturation value of dissolved oxygen. Included in

this figure 43 are the results of a series of analyses made across the stream and at various depths.

Q. Did you complete your answer, Doctor?

A. That is the answer which I supposed would meet the requirements of your question.

Q. You mentioned or testified in regard to these incubation tests. What do you infer from these?

3925 Mr. Riker: The objection to that is that it is not rebuttal of any testimony offered by the defense.

The Commissioner: Note the objection.

The Witness: An inference drawn from the incubation tests was that the amount of oxygen found in Harbor water when the samples was collected, and analyzed at that moment, did not indicate the total draft upon the oxygen which the sewage present in the water would make. On standing and giving the sewage opportunity to act over a period of time more oxygen would be taken from the water.

Q. Is it usual to test waters for stability by incubation, and state whether or not it is adopted in other countries than this country.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

The Witness: It is usual and is regarded in other countries, particularly in England as a desirable procedure.

Q. One of the witnesses for the defense, Dr. Soper, referred to diffusion experiments which appear on pages 457, 458, 459 and 460 of Complainants' exhibit No. 134, being the report of the Metropolitan Sewerage Commission of New York, 1910. I ask if you have any details as to experiments set forth on the pages that I have just enumerated, in addition to the details that appear on the pages which I have indicated, and if so, state those details?

Mr. Riker: The question is objected to on the ground that it is irrelevant and immaterial, and is not rebuttal of the testimony of the defendants, but deals with other facts not under consideration by the defendants' witnesses.

3926 The Commissioner: Note the objection.

The Witness: I have some further details other than those stated on pages of the report referred to.

Q. The details which I am most particular about, are the strength of the dye solutions employed in these diffusion experiments the direction of the currents, salinity of the water, and the intensity of the currents, and also the temperature of the water?

A. Do you wish me to make a statement of the data that I have here in regard to that?

Q. Yes sir?

A. The experiments to which I will refer relate to the year 1909 and to the location of a proposed point of outlet of the Passaic Valley Sewer. The experiments extend through the months of June July, August and October. On June 15th—I should say in regard

to the location at which these experiments were made, in some cases the experiments were made as close to the proposed site of outfall as could be determined from the report of the Passaic Valley Sewerage Commissioners of 1908. In some cases other points in the vicinity were chosen. On June 15th, at a point 250 feet east of Robbins Reef bell buoy one pound of uranine dissolved in 425 gallons of water, making a preparation of one part dye to 2,750 parts water was released. The temperature of the water was 66 degrees fahrenheit; the current was flowing ebb, and the salinity was 1.0115.

2827 *Diffusion Experiments Conducted by the Metropolitan Sewerage Commission at and Near the Site of the Proposed Outlet of the Passaic Valley Sewer.*

Date, 1909.	Stage of water Govs. Is	Tide.	Current.	Velocity.	Lbs.	Uranine. Dilution water, gals.	Uranine. Proportion.	Specif. grav. Dye liq.	Specif. grav. Harbor water.	Temperature—Degree F. Dye liq.	Temperature—Degree F. Harbor water.
June 15.	Low tide, 11.56 a. m.	Flood..	Flood..	.....	1	425 gals.	1/2750	1.000	1.0115	..	67
		Notes.—Uranine kept in band 5' wide and several hundred feet long.									
July 30.	Low tide, 11.47 a. m.	Flood..	Flood..	Moderate..	30	350 gals.	1/292	1.000	.....	..	..
		Notes.—The dye liquor was discharged 10' below surface. Uranine appeared at first near boat and later about ¼ mile away from boat.									
July 31.	Low tide, 12.42 p. m.	Ebb....	.....	1.51' per —	20	700 gals.	1/291	1.000	1.016	73	74
		Notes.—Dye water discharged in 27 feet. At 12.30 p. m. began pumping dye water. At 12.35 p. m. uranine seen 700' down stream. At 12.37 p. m. uranine seen 200' down stream. At 12.38 p. m. uranine seen 125' down stream. Sample collected at bottom 30' down stream showed a dilution of 1 part in 50,000. Sample collected 400' down stream showed a dilution of 1 part in 200,000.									
Aug. 2.	Low tide, 2.25 p. m.	Ebb....	Ebb....	2.4' per sec.	30	1,050 gals.	1/283	1.000	1.020	..	72
		Notes.—Dye liquor discharged at a depth of 25'. 12.12 p. m. began to discharge dye. 12.18 p. m. uranine noted 600 down stream. 12.25 p. m. brilliant green field noted 120' x 50'; ¼ mile down stream.									

Aug.	3.	High tide, 9.09 a. m.	Ebb....	Ebb....	Slow.....	30	1,050 gals.	1:280	1.000	1.020	71	71

NOTES.—10.44 a. m. Began pumping dye water at depth of 30'.
10.52 a. m. Raised discharge end of hose to 25'.
10.59 a. m. Stopped pumping.
11.14 a. m. Resumed pumping at depth of 30'.
11.16 a. m. Stopped pumping.
11.20 a. m. Resumed pumping at depth of 25'.
11.30 a. m. Color seen 100' from boat and another field 1000' from boat.
11.36 a. m. Resumed pumping at depth of 30'.
11.44 a. m. Color seen 500' distant on right hand 400' on left.
11.54 a. m. Color seen 1500' toward Fort Hamilton.

Aug.	5.	High tide, 10.40 a. m.	Ebb....	Ebb....	1' per sec...	10	600 gals.	1:500	1.000	1.020	67	70

NOTES.—Specific gravity of Harbor water-surface.....1.019.
" " " " " 20' deep.....1.020.
" " " " " 40' deep.....1.020.
12.35 p. m. Began Pumping at depth of 20'.
12.40 p. m. Color appeared 45' from boat.
12.42 p. m. Resumed pumping at depth of 25'.
12.55 p. m. Color appeared 800' from boat.
1.02 p. m. Resumed pumping at 40' deep.
1.20 p. m. Color seen 400' toward Hudson River.

Aug.	6.	High tide, 11.34 a. m.	Flood..	Flood..	2' per sec...	4	1,000 gals.	1:2000	1.000	1.019	..	70

NOTES.—Specific gravity at surface of Harbor Water.....1.018$\frac{1}{2}$.
" " " 20' deep.....1.019$\frac{1}{2}$.
" " " 40' deep.....1.020.
1.01 p. m. Began pumping at 40' deep.
1.15 p. m. Stopped pumping.
1.32 p. m. Resumed pumping at 25' deep.
1.48 p. m. Raised discharge to 20' deep.
1.54 p. m. Cruiser appeared 300' away.

Date, 1909.	Stage of water Govs. Is.	Tide.	Current.	Velocity.	Lbs.	Uranine. Dilution water, gals.	Uranine. Proportion.	Specif. grav. Dye liq	Specif. grav. Harbor water.	Temper'ture—Degrees F. Dye liq.	Temper'ture—Degrees F. Harbor water.
Aug. 13.	Low tide, 12.17 p. m.	Flood..	Flood..	1′ per sec...	5	300 gals.	1/500	1.000	1.017	66	72
		NOTES.—Specific gravity of Harbor Water surface.....1.016½.									
		" " " " " 20′ .....1.017.									
		" " " " " 40′ .....1.017½.									
		3.15 p. m. Began pumping at depth of 40′.									
		3.26 p. m. Pumping at depth of 25′.									
		3.28 p. m. Stopped pumping.									
		3.35 p. m. Color appeared 400′ from boat. Surface velocity, ¾′ per second.									
Aug. 4.	High tide, 9.15 a. m.	Ebb....	Ebb...	.....	20	700 gals.	1/290	1.000	1.020	70	70
		NOTES.—Color discharged at depth of 30′.									
		No uranine was discovered on the surface.									
		Owing to bad light, rain, and rough surface of water the color would have been difficult to detect.									
Aug. 11.	High tide, 4.35 p. m.	Flood..	Flood..	2′ per sec...	..	.....	1/2000	1.000	1.019	71	73
		NOTES.—Specific Gravity of Harbor Water Surface.....1.018.									
		" " " " " 20′ .....1.019.									
		" " " " " 40′ .....1.019½.									
		Color discharged at depth of 35′.									
		No color due to uranine was noted.									
Aug. 18.	High tide, 9.44 a. m.	Ebb....	Ebb....	1′ per sec...	..	.....	1/1000 1/2000	1.000	1.019	63	69
		NOTES.—Specific Gravity of Harbor water surface.....1.019.									
		" " " " " 20′ .....1.019½.									
		" " " " " 40′ .....1.019½.									
		Color discharged at depth of 30′.									
		No color was noted.									
Aug. 26.	Low tide, 9.12 a. m.	Flood..	Flood..	3′ per sec...	290	62,450 gals.	1/1789	1.003	1.016	65	72

3930 Notes:

Special	Gravity	at	surface	1.015
"	"	"	20′	1.016
"	"	"	40′	1.017

Color discharged from 8″ discharge pipe at a rate of 14.8 feet per second, at depths varying from 44 feet at start to 36′ at end of pumping period. No color was noted at the surface owing probably to the fact that the higher rate of discharge diffused the dye through a very large volume of sea water, thereby diluting it so that it could not be distinguished at the surface.

Q. What inference did you, Doctor, draw from these dye experiments to determine questions relating to diffusion and dispersion?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

The Witness: That sewage discharged at the same points and same stages of tide might rise to the surface of the water before becoming greatly diluted. A great many inferences and opinions were drawn from all of this experimental work, but as I understand it you care more for the things that impressed the Commission as essential and of chief importance than the minor considerations?

Q. Yes, sir. Would large volumes of sewage amounting to 360,000,000 gallons a day be more or less likely to appear at the surface than the dyes that you used in the strengths that you used in these diffusion experiments?

Mr. Riker: The same objection.
The Commissioner: Note the objection.
The Witness: More likely.
Mr. O'Sullivan: Your witness, sir.
Mr. Riker: No questions, sir.

Adjourned to Wednesday May 28th, 1913 at 10:30 A. M.

3931 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Before James D. Maher, Esq., Commissioner.

NEW YORK CITY, May 28th, 1913—10:30 a. m.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

SAMUEL A. GREELEY a witness called in behalf of the Complainants in rebuttal, being first duly sworn, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Mr. Greeley?
A. Samuel A. Greeley.
Q. Where do you reside, Mr. Greeley?
A. At Winnetka, Illinois.
Q. What is your profession?
A. I am a Sanitary Engineer.
Q. What is your present occupation?
A. I am an Assistant Engineer with the Sanitary District of Chicago.

Q. Where did you receive your professional training?
3932 State in full and what degrees you have received and where you received your technical training?

A. I received a scientific education, having special reference to sanitary engineering. I graduated at Harvard University in 1903, receiving the degree of A. B. I spent portions of the following three years studying sanitary engineering at the Massachusetts Institute of Technology, graduating with the degree of Bachelor of Science.

Q. When did you become actively engaged in the practice and practical duties of your profession?

A. I became actively engaged in the practical duties of my profession in June 1905. From then until May, 1908, I was engaged as assistant engineer with the firm of Hering & Fuller of New York City. During this time I worked in various capacities on the design and construction of works for the disposal of sewage and refuse and the purification of water.

Q. State some of the projects that you were connected with during that period?

A. Among the projects with which I was connected during this period the following may be mentioned: At Columbia, Pennsylvania, I served as resident engineer on the construction of a dam and reservoir for the water supply of the city. At York, Pennsylvania, I served at various times as assistant engineer on the construction of sanitary sewers and made special investigations for the protection of certain lands along the river from damages due to floods. In September, 1906, I took up a position in the New York office of the firm of Hering & Fuller and worked on the detailed plans for sewage disposal works at York, Pennsylvania; Reading, Pennsylvania; Allentown, Pennsylvania; Togos, Maine; the Montefiori Tuberculosis Sanitarium in New York; and at Madison New Jersey. I was connected with water purification plants at Bangor, Maine, and Burlington, Vermont, and with the investigation for additional water supply at Bellingham, Washington. The work at Bellingham, Washington, included a special trip to Bellingham for the purpose of going over the local situation with the city officials and completing the work necessary for a final report.

3933 During this period I worked on the engineering features of the design of the Passaic Valley trunk sewer. I also worked for a period of three months in the Department of Water Supply, Gas and Electricity of the City of New York, on the design of a sewage disposal plant for Mount Kisco, New York. I was further engaged on the valuations of the water works of the Monongahela Water Company and the water works of Cortland, New York. During the Winter and Spring of 1908 I worked up in detail the plans and specifications for the refuse incinneration plant for Milwaukee, Wisconsin. In May, 1908, I went abroad, traveling through Germany, France and England, making a study of works for the filtration of water and the disposal of sewage and refuse in the larger cities of these countries. This trip lasted until August, 1908. In Germany I inspected the sewage disposal works at Hamburg and Frankfort, and at other places.

Returning to New York about the first of September, 1908, I resumed my place in the office of Hering & Fuller, working first on the design of a sewage system and sewage disposal plant for Batavia, New York. I worked up in detail plans and specifications for refuse disposal at El Paso, Texas, and did additional work on the refuse disposal scheme at Milwaukee, Wisconsin.

In March, 1909, I went to Milwaukee as Resident Engineer where I had charge of the construction of a refuse incinneration plant for the city. I completed the construction of this plant in May, 1910, and in June following took charge of the plant as superintendent for the City. I continued as superintendent until August, 1911, when I again went to Germany. The purpose of this trip was to secure, in particular, data relative to the collection of refuse, in order to better operate the collection service in Milwaukee. I also was particularly requested to inspect the sewerage works at Hamberg, Dresden, Frankfort and Essen, in order to secure data that would be helpful in carrying out a project for sewage

3934 disposal in Milwaukee recommended by a commission made up of Mr. Eddy of Boston, Mr. Whipple of New York, and

Mr. Alvord of Chicago. I returned from this trip late in September and for a few weeks resumed my position in Milwaukee as superintendent of the refuse disposal works.

In October, 1911, I accompanied Mr. James H. Fuertes of New York to Caracas, Venezuela, to assist in the preparation of a report upon the water supply, sewerage and sewage disposal for that city. Mr. Fuertes left me in Caracas in charge of the investigations. I returned from Caracas in December, 1911, and prepared a report on the work for Mr. Fuertes.

In February, 1912, I became associated with the Sanitary District of Chicago as assistant engineer in the sewage disposal division of the Engineering Department. My work in this position has included investigations, reports and designs for sewage disposal in the vicinity of Chicago. In particular, I made detailed reports upon the disposal of the sewage in the so-called "Calumet" district in Indiana, and upon the sewerage and sewage disposal of the northern part of the Sanitary District. During the Summer of 1912 I prepared plans and built a sewage testing station for the packing house district of Chicago. I have also had immediate charge, under the Division Engineer, of the preparation of plans for a settling plant project for a district of approximately 25,000 people on the west side of Chicago. One of the chief features of my work with the Sanitary District has been the design and general supervision of the construction of numerous settling tanks for the treatment of trade wastes from individual factories.

Before my association with the Sanitary District of Chicago I had undertaken a certain amount of consulting work which it has been necessary for me to continue. I am at the present time serving as consulting engineer on refuse disposal to the Commissioner of Public Works of Detroit, Michigan. I am also acting with the city engineers of Winnetka, Illinois, and Lake Forest, Illinois, as
3935 consulting engineer on sewerage and sewage disposal work.

I have throughout the Winter consulted with Mayor Bading of Milwaukee on preliminary work relating to the necessary legislation for the formation of a sewerage commission for that city.

During the winter of 1912 I have given special lectures at the University of Illinois, Medical School, and at the University of Chicago, upon the subject of refuse disposal.

I have from time to time published numerous papers relative to refuse disposal and sewerage matters. My work with the Sanitary District has given me particular opportunity to measure the flow in sewers and the rainfall on the sewerage districts, and I have reported the results of this work in a paper before the Western Society of Engineers.

Q. Mr. Greeley, have you examined the testimony given in this case by Mr. William H. Brown, Chief Engineer of the Passaic Valley Sewerage Commissioners?

A. I have, in a general way.

Q. Have you had any connection with the sewage disposal of Boston, which Mr. Brown speaks of in his testimony?

A. Yes. During the Winter of 1905 I started an investigation of

the composition of Boston sewage and its disposal and dispersion in Boston Harbor. This work was undertaken as thesis work in conjunction with Mr. Charles Saville.

Q. Did you complete this work?

A. No. The work was only partly finished. We were making 24-hour tests upon the chemical composition of Boston sewage to ascertain the variation in the composition. During the second of these tests Mr. Saville and I both contracted typhoid fever of such a severe character that the work was necessarily closed without being completed.

During the time of these investigations, Mr. Saville and I were living together at a fraternity house with two other men, all of us eating the same food and drinking the same water, and of the men at this fraternity house we were the only two to take typhoid fever, and we came down with it, at approximately the incubation
3936 period, at the date of the test of the Boston sewage at Deer Island.

Q. Were any of these other men engaged outside of Mr. Saville and yourself in these tests you have described on the Boston Sewage?

A. No, we were the only two.

Q. Where were those tests conducted, Mr. Greeley?

A. One of the tests was at the Cow Pasture Pumping Station, and the other was at the Deer Island outlet.

Q. Have you examined the testimony given in this case by Mr. George A. Johnson?

A. Yes, I have.

Q. Did you find that on page 3959 of his testimony he stated that the field force under his direction, in connection with the chemical and bacteriological work done by him in the Fall of 1907 for the Passaic Valley Sewerage Commissioners, was in your charge?

A. Yes.

Q. What connection did you have with the work done by Hering & Fuller under Mr. Johnson's direction for the Passaic Valley Sewerage Commissioners? Was it in your charge?

A. No. My work related chiefly to engineering details required for the computation of the proper size and slope of the proposed trunk sewer. In this connection I made personal examinations and estimates of the distribution of population over the district tributary to the proposed trunk sewer, and assisted in the determination of the quantity of sewage which might enter the trunk sewer at various points along its length, so that the proper proportions could be determined. I had no connection with the chemical and bacteriological work done at this time.

Q. Have you read Mr. Johnson's testimony, given on pages 4040, 4041 and 4048?

A. Yes.

Q. With reference to sewage screens and their efficiency?

A. Yes.

Q. In this part of his testimony Mr. Johnson states on page 4040: "The amount of suspended matter removed by screens will vary from

15 to 50 per cent. of the total suspended matter contained
3937 in the sewage. The screens that I have referred to as removing 50 per cent. of the suspended matter are of the type used in Dresden where the sewage, after passing through the grit chamber, is passed through a disk screen which is about 5 feet in diameter and has openings about 1/12 of an inch in the clear." I direct your attention to page 4041 of Mr. Johnson's testimony given in this suit. He states: "I have figured that about 20 per cent. as a maximum should be anticipated as the efficiency of these fine screens or screens having openings of 4/10 of an inch." Mr. Johnson further stating in his testimony in this suit on page 4048: "I feel that in the screening device there will be removed suspended matters amounting to in round numbers 15 per cent. of the total suspended matters in the crude sewage." Mr. Johnson computing from data given in Doctor Dunbar's book, entitled "The Principles of Sewage Treatment," that the removal of suspended matter by screens of the type used in Hamburg, where the opening between the bars is approximately 4/10 of an inch, would be 26.7 per cent. This he states, quoting his language, "is in excess of the figure I have just stated and is based on actual results with a screen of a type in general accord with the screen described in the stipulation."

Now, referring to Complainants' Exhibit 135, which I hand you, is the result of your knowledge and observations of sewage screens in actual operation in accord with these statements, to which I directed you and which have been testified to in this suit by Mr. George A. Johnson?

A. No, it is my observation that the removal of total suspended matter by screens of the types used at Hamburg and Dresden when applied to the Passaic Valley sewage will not be as great as 15 per cent., and will probably not exceed 10 per cent. as a maximum, and will probably average less than 10 per cent.

Q. On what do you base that statement?

A. I base my statement on the results of personal observations of the operation of the sewage screening plants at Hamburg, Dresden and Frankfort, Germany, and on the data given to me by
3938 the men in charge of those plants as to the quantities removed, and on reports of tests made of the percentage removal of total suspended matter at these plants.

Q. Directing your attention again, Mr. Greeley, to the testimony given in this suit by Mr. Johnson, and particularly to page 4051 of his testimony, in answer to the question: "Could these works be operated on the Newark Meadows without giving rise to nuisance of offence of any kind?" he answered: "I believe that they could, basing my judgment on personal observation of sewage works in this country and abroad, in England especially, where such works as these are immediately alongside of public highways and close enough to toss a stone into, and in some cases residential sections of some class." Was you observation of the sewage screening plants in Germany in accord with this statement?

A. No; the handling of screenings removed by the screens from the sewage at the plants mentioned created a nuisance. I found dis-

tinct odors similar to those from a pig-pen coming from the screenings stored at the Dresden plant and from the screenings which fell from the conveyors used to handle the screenings at Hamburg and Frankfort. The disposal of the screenings from the Hamburg screens upon the low lands, down stream from Hamburg, was particularly obnoxious.

Q. Directing your attention again to Mr. Johnson's testimony as given in this suit, and particularly to page 4156 of his testimony where Mr. Johnson is reported as stating "as a general rule the screens are about 15 feet in diameter and built circular." This statement refers to the Dresden screens. Did you find the screens at Dresden to have this diameter during your examination of them?

A. No; I found the diameter of the Dresden screens to be 8 meters or 26.24 feet.

Q. Was the Dresden plant in operation in 1908, the date of the publication of Dr. Dunbar's work entitled "Principles of Sewage Treatment" from which Mr. Johnson quoted during his testimony?

A. No.

Q. The screening plant at Dresden went into operation during the Winter of 1910 and 1911?

3939 Mr. Riker: The question is objected to as not being rebuttal.

The Commissioner: Note the objection of Counsel for Defendants.

Q. Will you describe more in detail the observations which you made of the sewage disposal works in Hamburg, Dresden and Frankfort, stating the year and the month when you made the observations and examinations?

A. I have here a report of the observations and visits which I made and from which I will read part. I proceeded first to Hamburg, Germany, where I spent August 30th and 31st and September 1st, 1911. Hamburg is a city of about one million inhabitants in Germany, on the River Elbe. The river divides the town into a larger northern section of about 850,000 people, and a smaller southern section of about 150,000 people. Near the center of the northern district is a larger lake or basin, called the Alster; and there are several small streams and canals throughout the city. The whole city is sewered on the combined system, and there are numerous overflows for storm water at various points throughout the city. The sewage of the northern district is all conducted to one main point of discharge into the Elbe river. The sewers leading to this point of discharge are large, smoothly built, well ventilated, and have good slopes, so that the sewage reaches the point of discharge in a fresh condition, without much odor. Herr Brunotte told me that the minimum velocity of flow in the system was 0.6 meters (1.97 ft.) per second, but that this minimum was confined to a few small sewers and that in the main trunk sewers the velocity of flow was about 1.0 meters (3.28 ft.) per second. He estimated that the time of flow for most of the sewage coming to the northern district point of discharge was from two to four hours, depending upon the volume of sewage flowing in the sewers.

The Elbe river, as it flows through Hamburg, is a tidal stream, the water being yellow-colored and turbid, with a fine "mucky" sort of suspended matter. Above the town it is used for the city water supply and is not strongly colored or turbid, but requires filtration to make it a clear, safe drinking water. The range of the tide is about 3 meters, 9.8 feet, but the stage of the water at Hamburg varies with the wind. The Sewage Screening plant of the
3940 northern district consists of coarse bar screens at the end of the main sewer and small grit chamber and revolving mechanical screens of the belt type. In this plant there is one grit chamber at the end of which are two screens. The bars of these screens are spaced 15 millimeters in the clear, and the screens are each 3.3 meters of 10.8 feet wide. The screens travel at the rate of about 2 meters or 6.56 feet per minute, and have only one speed of operation. The average quantity of sewage flowing through this plant is 190,000 cubic meters per 24 hours, equivalent to 50,000,000 gallons per day. The grit chamber is cleaned two or three times a week, the cleanings amounting to from 12 cubic meters or 15.7 cubic yards to 16 cubic meters or 20.9 cubic yards, daily, the average removal being 20 cubic meters or 26.1 cubic yards per day of wet screenings. The sludge and screenings are dumped into covered steel barges which are towed to the dumping grounds, several miles below the city. After the sewage passes through the screens, there are five discharge pipes through which it may pass into the river. Ordinarily only three of these are used; the other three, which extend into the river, 70 meters, 100 meters and 133 meters from shore respectively; and all are turned up 90 degrees at the end and discharge at the bottom of the river. A new screening plant serving the southern district of Hamburg has been built and is operating very much below capacity because the intercepting sewers had not yet been completed. I visited the two screening plants on August 30th, 1911 in company with Mr. Helmke an assistant of Dr. Brunotte's, in charge of sewage disposal. On August 31st, I again visited the old plant and then took a launch and spent the day on the river visiting the plants where the sludge and screenings were disposed of. On September 1st, 1911 I called on Dr. Brunotte again questioning him with reference to certain points about the disposal methods.

Q. Who is Dr. Brunotte?

A. Dr. Brunotte is the engineer in charge of sewage disposal in Hamburg. Referring to the visit made on August 30th, 1911, Mr. Helmke and I left Dr. Brunotte's office about 1:30 P. M. and proceeded by trolley, ferry and on foot to the new screening
3941 plant on the south side of the Elbe. The general appearance of the plant, as we approched it, was attractive and no sewage odor was noticeable until we had entered the grounds. From the new plant we went by the city's launch to the old plant, and on the way there was good opportunity to observe the Elbe water. This was in all places a yellowish brown, without many large floating matters. The river was very choppy and they say, always is, so that there is very little opportunity for sleek to collect on the surface. Here and there I saw blotches of it, about 12 inches in

diameter. As we came within 100 yards of the plant, there was noticeable a sewage odor. The buildings and grounds of this plant were also attractive. Entering the screen room, there was noticeable a sewage odor but not outside the plant. The sewage appeared fresh but did not smell strongly. The depth of sewage in the grit chamber, I measured to be 3 meters and it was flowing through at a good velocity. After inspecting the plant we went in the City launch to a point just over the outlets. Mr. Helmke pointed out the location by some floating matters and white froth or foam on the surface. There were sea gulls, although I had seen them nowhere else. On the day of my visit, it was cool and there was a good breeze blowing from just west of north. The river was very choppy. I could not see any marked evidences that sewage was being discharged into the river, except the gulls. On August 31st, 1911, I went first to the old plant and then took a launch with an English speaking engineer to visit the place called Newenfelde, where the screenings from the plants are disposed of. I have here some photographs which I took at Hamburg, illustrating the place of disposal of those screenings.

Q. Who took those photographs?

A. I took them.

Q. Where were they developed?

A. They were developed and printed in Hamburg. We reached Newenfelde, the place where the point of disposal of the screenings was, about noon, and had a two mile walk to where the tank boats from the sewage plants were unloaded. The country we walked through was wholly devoted to truck gardens and orchards, and the whole neighborhood smelled of the pig pen odor
3942 from the sewage screenings used as fertilizer. The unloading station is located on a small creek and was very foul. It consists of only an inlet for docking the tank boat, a derrick, some trucks and a narrow gauge, movable track. These are illustrated in the photographs. The derrick is used to lift the body of the truck from the frame to the boat. There it is filled with a shovel and then replaced on its frame, and the whole car is then run out onto the dump.

Well, going back from the point of disposal of screenings I observed carefully the Elbe water, taking samples about 6 inches below the surface in a bottle. These samples were colored a yellowish brown which did not increase on standing 24 hours. In each of them there was a fine mucky sediment. It had a slightly salty and fishy odor and contained a fine yellowish mucky suspended matter.

As a summary of the observations made during the three days at Hamburg, I would state that the discharge of effluent from the sewage screening plants of Hamburg into the Elbe did not add seriously to the turbid appearance of the water, the Elbe itself being a colored turbid water at that point. The absence of a discernable sewage field was due to the dispensing of the sewage in the water through the agency of the ships, tugs and tides which intersect the water at many angles and keep the water continuously churned up. There were evidence of sewage pollution, such as the

presence of gulls, the sleek near the docks and the floating particles. The greatest nuisance from the plants came from the handling of the sludge and screenings at the plant and from their ultimate disposal on land.

After visiting Hamburg I proceeded to Dresden, where I spent September 2nd, 1911. Dresden is also located on the Elbe River, the sewage disposal plant being located on the Elbe below the town. Dresden is sewered on the combined plan. There are two main intercepting sewers, one on each side of the river. The superintendent at the screening plant told me that the time of flow of sewage from the center of town to the disposal plant was only about one half hour, and the time of flow for most of the
3943 sewage did not exceed 2¼ hours from the point of entrance into the sewer to the disposal plant. The disposal plant where the sewage is screened, is located well below the town in open country, on a large tract of farm land owned by the city. The disposal works consist of coarse bar screens and main screen house in which are located four large disc screens, and a pumping station, and various other office buildings, and a house for the workmen. The main revolving mechanically cleaned screens are of the "Riensch" disc type and are each 8 meters or 26.24 feet in diameter. I have a plan and photograph of one of the screens here—a plan of the plant and a photograph of one of the screens. They revolve at two speeds, one revolution at 2 minutes and one revolution per 3 minutes. They are run generally at the lower speed. The slits through which the sewage passes are 2 millimeters or .078 inches wide on top, 3 millimeters or .117 inches wide on the bottom, and 30 millimeters, or 1.17 inches long. They are made of brass plates, 5 millimeters or .196 inches thick on the disc and 4 millimeters or .157 inches on the cone at the center of the disc. The maximum loss of head in going through a screen is 60 centimeters or 23.6 inches, or about 2 feet. The screens are cleaned by revolving brushes, which scour the screenings off the screen into a conveyor, which discharges them into small cars in which they are conveyed to the dumps in the yard.

I went to the Sewage Disposal Works by trolley along the south side of the river as far as Mohn street, which is the end of the line, where I walked along the river, then through a suburb, and finally through open fields, to the plant—a total walk of about 1½ miles. I learned from Mr. Scheitzow——

Q. Who is Mr. Scheitzow?

A. The Superintendent of the plant. I learned from him that the quantities of material removed from the sewage at the disposal works were as follows: From the two grit chambers, one cubic meter or 1.3 cubic yards; from the scum boards and bar screens,
3944 one cubic meter, or 1.3 cubic yards, daily; from the revolving screens, 10, or 13.0 cubic yards, to 12 cubic meters, or 15.7 cubic yards, daily. Then I went through the plant with the superintendent. The material removed from the sewage is piled in the yard and either given away or sold as fertilizer. I walked from the plant down the river about one third of a mile to the sewer outlet and then about one mile further down to the ferry where I

crossed over to the north side of the river. The river water was dirty and dark appearing all the way down. From the sewer outlet to the ferry, I noticed a slight but distinct odor, and there were blotches of sleek evident on the surface. The summary of these observations is that the discharge of the effluent from the sewage screening plant into the Elbe increased the unpleasantness of the river water. There were evidences such as sleek which collected along the shore, and the floating particles and the sewage odor; that the greatest odor from the sewage treatment came from the storage and distribution of screenings.

Q. Now as to Frankfort.

Mr. Riker: One moment. I object to Frankfort on the ground that that is not rebuttal.

The Commissioner: Note the objection of Counsel for the Defendants to the question.

Q. Just summarize in as few words as you can, the observations at Frankfort, giving the size of the screen mesh and the resulting effluent and whatever it occasions?

Mr. Riker: The objection is renewed to the question as revised on the ground that it does not call for rebuttal testimony on any evidence of the defendants.

The Commissioner: Note the objection of Counsel for the Defendants.

A. At the plant at Frankfort there are three screens of the paddle wheel type, each screen being 2 meters wide and the clear
3945 spacing between the bars is 10 millimeters. The screens are cleaned mechanically. The quantity of screenings removed——

Q. 10 millimeters would be what in inches?

A. 0.39 inches. The screenings removed amount to 19.9——

Q. Can you give me that in the fraction of the inch?

A. It is somewhat less than 4/10ths. I inspected this plant on September 4th, 1911. The summary of the observations at this plant is that the discharge of the effluent from the sewage disposal works into the Main materially increased the insightliness of the water, and there were evidences of sewage pollution, such as the boiling or bubbling up of the sewage plant effluent in the river water and the clearly marked sewage area extending down stream from the point of discharge. The city, after disposing of the sludge and screenings on land for a number of years, had gone to great expense to dry and then burn the sludge and screenings from the sewage works.

I have in conjunction with these observations secured certain maps and descriptive pamphlets substantiating the observations and amplifying them, which are attached to the report as certain appendices listed and mentioned in the written part of the report.

Q. You may describe these appendices without using any words from the report.

Mr. Riker: If that is in the form of a question is it objected to as not being rebuttal, being immaterial and irrelevant and not the best evidence.

The Commissioner: Note the objection of Counsel for the defendants.

A. Appendix I is List of the Drawings and Documents secured. Appendix II is a Tide Table for Hamburg, setting forth the stage of the tide at the time of my visit there. Appendix III-A is a Descriptive Pamphlet with maps of the sewers and screening plant at Hamburg.

3946 Q. Where did you get that?

A. I got that from the Sewer Department in Hamburg; Appendix III-B is a description of the screens by the manufacturers and is a trade document published in Germany. Appendix IV is a Map of Hamburg, showing the course of the river to the city. Appendix V is a book which I bought in Hamburg, being a report on Investigations of the Elbe River at Hamburg and takes up the biological condition of the river as influenced by the sewage discharged into the river. Appendix VI is a Map of Dresden. Appendix VII is a description of the Sewage Purification plant and Sewage Screening Plant at Dresden given to me by the Superintendent of the plant. Appendix VIII is a map of Frankfort; and Appendix IX is a description given to me by the Engineer in the City Hall in charge of Sewage Disposal, as a correct description of the sewage screening plant at Frankfort.

Q. Mr. Greeley, directing your attention again to the testimony given by Mr. George A. Johnson on page 4040 from which I quote: "The amount of suspended matter removed by screens will vary from 15 to 50 per cent. of the total suspended matter contained in the sewage, through a disc screen which is about 5 feet in diameter in the clear." I ask you after directing your attention to that testimony, if any of these screens will remove that percentage of suspended matter?

A. No; it is my observation that the sewage screens at Dresden do not remove 15 per cent. or greater of the total suspended matter.

Q. How about Hamburg and Frankfort?

A. The same is true of Hamburg and Frankfort.

Q. Did you prepare a report on the observations that you have testified to and of the photographs that you took, that you say you had developed in Hamburg?

A. Yes, I have a report here which I prepared after returning from the trip.

Mr. O'Sullivan: I offer that report in evidence and ask that it be marked Complainants' Exhibit No. 204.

3947 Mr. Riker: The offer is objected to on the ground that the report is not evidence, that it is immaterial and irrelevant, and is not rebuttal, and that the contents of it is not relevant to the issue.

The Commissioner: Note the objection of Counsel for the defendants.

Received in evidence and marked Complainants' Exhibit No. 204.

Q. Mr. Greeley, what was the most distinctive feature of the sewage treated at the screening plants at Hamburg, Dresden and Frankfort, based on your observations and inquiries as it relates to the efficiency of screens of this type?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence on behalf of the defense.

The Commissioner: Note the objection of Counsel for the Defendants.

A. I found the most important characteristic of these sewages to be their freshness.

The matter removed from the screens consisted largely of large pieces of fecal matter, unbroken up. The sewage was not dark-colored or septic in appearance and did not have the odor characteristic of old sewage.

Q. Did you make any effort to ascertain approximately the age of the sewage as it reached the plants at these cities, which I have just named?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes. I have made such inquiries and have recorded the results of the inquiries in this report, and have already referred to them.

Q. Complainants' Exhibit No. 204?

A. Complainants' Exhibit No. 204. The time of flow for most of the sewage coming from the screening plant at Hamburg was from two to four hours.

Q. Mr. Greeley, you stated that you found that the removal of total suspended matter in the sewages of the cities of Ham-
3948 burg, Dresden and Frankfort by the screens was not in excess of 10 per cent. Upon what data do you base that statement?

A. I base it in particular upon the actual quantities removed as given to me by the Superintendents in charge of the plants and on the results of analyses contained in a report of the Sewerage Department of Frankfort, made to the Government upon the Pollution of the Main River dated 1908.

This report contains a summary of a number of experiments, chemical experiments, made by several collaborating chemists, whose names are placed on record in the report. It is stated on page 5 of that report that the total suspended matter——

Mr. Riker: I object to the reading of this report into the evidence, as not being properly proved, not being evidential, and not being rebuttal.

The Commissioner: Note the objection of Counsel for Defendants.

2613

The Witness (continuing): On page 5 of this report it is stated that the total suspended matter in the raw sewage amounts to 410 parts per million; that there is removed by the screens 21 parts per million. There is, therefore, a percentage removal of 5.12 per cent. I was unable to secure similar analytical data for the plants at Hamburg and Dresden.

Q. Can you give an estimate or approximation of the quantities of screenings removed each day from the reports furnished you by those in charge of the operating plants at the points that we have just been questioning about, at Hamburg, Dresden and Frankfort?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. Only upon the assumption that these wet screenings contained approximately a certain percentage of moisture.

Q. What percentage would your observations and inquiries indicate to you as being a reasonable minimum quantity of
3949 water or of moisture contained in the screenings?

Mr. Riker: The question is objected to on the same grounds, and also on the ground that the hypothesis upon which the question is based is not proven in this case.

The Commissioner: Note the objection of Counsel for the Defendants.

A. About 70 per cent.

Q. Assuming that the screenings removed in the quantities given you by those in charge of the plants at Hamburg, Dresden and Frankfort contained 70 per cent. of moisture, what is the percentage removal of total suspended matters by the screens at Hamburg and Dresden?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. I find that at Hamburg the screens removed suspended matter that amounted to 10.5 per cent. of the total suspended matter and at Dresden to about 11.2 per cent. of the total suspended matter.

Q. In your opinion are these percentages greater or less than the percentage that would be removed by screens having clear openings of about 4/10ths of an inch similar to those in operation at Hamburg and as proposed by the Passaic Valley Sewerage Commissioners?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I consider these percentages to be greater than the average to be expected.

Q. How do the screening plants at Hamburg and Dresden compare with other screening plants?

A. They are among the best screening plants in operation. They are very carefully and well operated. The plant at Dresden is one

of the best built that I have seen and they are good representatives of screening plants of their types.

Q. In your opinion would the sewage of the Passaic Valley
3950 trunk sewer contain as great a proportion of sufficiently large suspended matters to be retained on a screen having 4/10ths of an inch clear opening as do the sewages in Hamburg, Dresden and Frankfort?

Mr. Riker: Some objection.

The Commissioner: Note the objection.

A. No. In my opinion the longer time interval elapsing between the origin of the sewage in the various cities along the Passaic River and its mode of delivery to the screening works and the comminuting would reduce materially the size of the particles, making up the suspended matter in the sewage.

Q. How would this comminuting action affect the percentage removal by the proposed screens of the total suspended matters, the screens being approximately 4/10ths of an inch in mesh?

A. In my opinion the total suspended matter removed by screens having an opening of 4/10ths of an inch in the clear, from sewage of the age and condition to be expected from the Passaic Valley trunk sewer would be materially less in amount than the 10 per cent. of suspended matter I have previously stated.

Q. Mr. Greeley, have you studied Complainants' Exhibit No. 135?

A. Yes.

Q. Can the effluent stipulated for or the results guaranteed in that stipulation be produced by the plant described in that stipulation?

A. It is my judgment that they will not.

Q. From your knowledge, experience, observation and researches in sewage disposal on the operation of screens and sedimentation plants and basins; from your researches as to the septicity of sewage, the time it takes to become septic, in your opinion will the sewage contemplated to be taken into the Passaic Valley trunk sewer be septic or not at the time it reaches the trunk Sewer outfall at Robbins Reef?

A. I should say that it would be septic.

Q. Would or would not such sewage as I have described in my preceding question occasion a nuisance, and if so, state what kind of a nuisance?

3951 A. I should say that it would create a nuisance resulting from odors.

Q. And as to sight, what would you say?

A. I should say that the septic action as affecting the action of streams would make the removal of suspended matter less, and tend to increase the evidence of sewage in the harbor waters.

Q. What would be a main feature of difference between the sewages that you observed at Hamburg and Dresden and the Passaic Valley Trunk Sewages that would be delivered at the Newark Meadows?

Mr. Riker: The question is objected to as not being rebuttal.
The Commissioner: Note the objection.

A. I think the chief difference would be as to the freshness of the sewage, as that related to the size of suspended particles contained in the sewage.

Q. Does screening affect equally, so far as the removal of suspended matter is concerned, fresh sewage and septic comminuted sewage?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. No.

Q. Well, what is the difference in your experience, Mr. Greeley?

A. The fresh sewage contains the suspended matter in larger particles, which are more readily removed by screens having clear openings about 4/10ths of an inch.

Q. What does septicization and comminution do with respect to sewage and the screening of that sewage?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. It has an effect upon the efficiency of the screening, lowering the same.

Mr. O'Sullivan: Your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. Are you a physician?

A. No, sir.

Q. Know anything about the causes of typhoid fever?

A. Something.

3952 Q. How did you gain your knowledge?

A. Through studies, chiefly.

Q. Did you drink any waters from New York Harbor?

A. No.

Q. You and your companion were afflicted with a case of typhoid fever, were you?

A. Yes.

Q. Do you know of any way in which typhoid can be given to a human being except through taking it in through the intestines, taking the germs in through the intestines?

A. Well, it can be taken in with drink or with food.

Q. Do you think that the experiences in the examination of the waters of New York Harbor had anything to do with your typhoid?

A. Why, I think the question is——

Q. Well, answer the question. It is not necessary to give your thoughts about it. Answer it, if you can.

A. Relating to the waters of New York Harbor, I do not think the experiences—I am not clear as to just what is meant by the experiences.

The question was then read by the stenographer.

Q. Do you think that the examination of the waters of Boston Harbor had anything to do with your typhoid?
A. Yes, I think they had.
Q. What?
A. I think that the examination of the sewage discharged into Boston Harbor was directly responsible for my typhoid fever.
Q. In what way?
A. In that I directly took typhoid germs from the sewage into my system.
Q. How did you take them in, in your opinion?
A. In making chemical analyses, we used a small tube in which we drew up samples of the sewage by suction. It is our belief that in that operation and in the late hours of the morning when we were tired and somewhat careless we became infected with the typhoid.
Q. You took, then, at practically the outlet of the Boston sewers, or from waters taken from the outlet of the Boston sewers into your mouth infected water, in your opinion?
A. Yes.

Q. Did you ever try the taking of the waters of New York
3953 Harbor, as they exist now, into your mouth?

A. No.
Q. To see whether you would get typhoid from it?
A. No.
Q. Why did you examine the sewage disposal works at Hamburg, Dresden and Frankfort?
A. As I already stated in order to gain data that would be of assistance in working out plans for sewage disposal for the City of Milwaukee.
Q. Why did you select those particular three places?
A. As having particular reference—as being particularly good examples of sewage screening plants.
Q. As being the best known disposal plants on a large scale that existed so far as you were informed, wasn't that it?
A. More particularly as relating to screens.
Q. Do you know of any sewage plants in existence for the disposal of sewage in a large way which are superior to those of Hamburg, Dresden and Frankfort.
A. As far as the disposal of sewage goes, I think there are several.
Q. Where are they?
A. Essen, Germany, I would mention as one; in Birmingham, England.
Q. Any others?
A. No, those are the only two I think of now.
Q. In what respect do the disposal works at Birmingham excel those at Hamburg, Dresden or Frankfort?
A. They give a greater purification of the sewage.
Q. In what way do they accomplish it?
A. They have additional works other than the screens.
Q. What additional works?
A. Sedimentation basins and sprinkling filters.

Q. Neither at Hamburg, Frankfort nor Dresden is there any sedimentation process is there?

A. There is sedimentation at Frankfort.

Q. To what extent?

A. They have, following the screens sedimentation basins.

Q. Does the sedimentation system at Birmingham provide a detention period of not less than one hour at the maximum rate of flow of the sewage and a detention period of daily average
3954 flow of such sewage for not less than 1 hour and a half?

A. I have not those figures in mind now.

Q. Can you by resorting to your data determine whether or not the Birmingham system provides for as great a detention period as is indicated in that question?

A. No, I could get it only from such books which I have here.

Q. Well, can you compare then the efficiency of the Birmingham sedimentation tanks with those that are described in Complainants' Exhibit No. 135?

A. No, sir.

Q. You do not know whether they are superior or inferior at Birmingham to those that are provided for in the stipulation?

A. No, sir.

Q. What do they have at Essen that they do not have at Hamburg, Dresden and Frankfort in the way of purification processes?

A. They have a number of sedimentation plants.

Q. Anything else?

A. I would state particularly as a feature of their sewage purification scheme that the sedimentation plants are located as near the origin of the sewage as possible.

Q. Yes. You volunteered that, but I want to know what else. What other process have they at Essen that they have not at Frankfort, Hamburg and Dresden?

A. They have none.

Q. In what respect then, does the Essen plant exceed in efficiency that proposed by the stipulation which is Complainants' Exhibit No. 135?

A. I cannot answer that on account of the fact that I do not know in detail what is proposed in the Exhibit No. 135.

Q. You have not examined the exhibit?

A. Yes, I have examined it.

Q. But you do not know what it contains?

A. Not in detail; not what the proposed sedimentation basins are to be.

Q. And you mean to say that you have undertaken to testify as to the probable effluent from this plant without acquainting yourself with what the processes are that are prescribed in this stipulation?

A. Yes, as nearly as can be done on the description presented.

3955 Q. Then you are familiar with the description as presented?

A. Yes.

Q. And you are familiar with what is prescribed as to sedimentation?

A. Yes.

Q. Well, why did you say that you were not?

A. I said that I was not able to compare that with the actual working settling plant as you requested me to do with the plant at Essen.

Q. And you did not say that you were not familiar with what was prescribed in the stipulation?

A. Yes.

Q. Then if you are not able to tell what the actual results and operation of the plants that is prescribed in the stipulation may be, how can you testify as to the probable result of the effluent when delivered into the waters of New York Bay?

A. What is that question?

The Question was read by the stenographer.

The Witness: In accordance with the stipulations I can testify as to whether in my judgment the works described in general in the stipulation will fulfill those requirements.

Q. Well, do you think your judgment has any value based upon any such supposition as that?

A. I think it has.

Q. Then in your observation and to your knowledge, is there a plant in actual operation, which in your opinion is more efficient in actual operation than that prescribed in this stipulation, when treating sewage on a large scale, with the exception of Birmingham?

A. That I am unable to answer.

Q. Cannot give an opinion on it?

A. No.

Q. Why not?

A. The details of the plant are not sufficiently set forth to compare with particular plants.

Q. How do you undertake to predict what the effluent will be then, if the details are not sufficient for you to determine what the operation of the plant will be?

A. I have not predicted in detail what the effluent will be.

Q. How are you able to predict in a general way what the
3956 result of the effluent will be if you are not willing to say that you understand what kind of a plant will be erected in accordance with these specifications?

A. I understand in a general way what kind of a plant will be erected and can state what its general effect will be.

Q. Then in the general way in which you understand the effluent as likely to be produced under these specifications, how will it compare with other plans that you know of for the treatment of sewage on a large scale?

A. I should say that it would be less efficient than a number now in operation.

Q. Which ones?

A. I have already referred to those at Essen and Birmingham.

Q. In what respect will it be less efficient than the one at Essen?

A. It will produce more of an odor, will remove less total suspended matter, and the discharge into the water will be more evident.

Q. Now, with reference to the odor, why do you say that it will produce more odor?

A. Because of the age of the sewage.

Q. That is the only reason?

A. Yes.

Q. Has that anything to do with the character of the plant?

A. That particular statement has not.

Q. Then so far as the treatment plant is concerned, that has nothing whatever to do with the question of the odors?

A. Well, I would not say yes to that.

Q. Well, what would you say to it? Say what you please to it, only give an answer to it.

The question was read by the stenographer.

A. Yes, I think it has something to do with the question of the odors.

Q. Yes; what has it to do with the question of the odors, itself as compared with the plant at Essen?

A. In the first place the method of removing suspended solids by screns in my observation and judgment, is a great deal more likely to produce odors, than the method in operation at Essen.

3957 Q. What is the method at Essen to which you refer, which is superior to that which is proposed in this stipulation?

A. Sedimentation tanks of the double-deck type, located as nearly as possible to the origin of the sewage.

Q. Well, have you studied the sedimentation tanks that are described and prescribed in the stipulation which is Complainants' Exhibit No. 135?

A. I have not studied them as regards drawings or details, no.

Q. Can you say whether they are likely to be more or less efficient than those at Essen without such an examination.

A. I should say that any settling tanks built to treat sewage of the age to be expected in the Newark Meadows from the Passaic Valley Trunk Sewer would probably be less efficient than those located at Essen.

Q. That has to do, however with the age of the sewage and not with the design of the sedimentation tanks, isn't that so?

A. Principally.

Q. Unless you know what is actually intended by the stipulation and the settling tanks therein described, how can you say whether they are likely to be more or less efficient than those at Essen upon the same class of sewage?

A. I cannot, based upon the same class of sewage.

Q. Are you prepared to say that the settling tanks that are described in this stipulation which is Complainants' Exhibit No. 135 will be less or more efficient than those at Essen and operated upon the same class of sewage?

A. No.

Q. Don't know anything about it?
A. No, I cannot make a definite answer.
Q. Now, at Birmingham you say they have introduced into the disposal works, sprinkling filters?
A. Yes.
Q. That is the only thing that is superior to the Essen plant?
A. That is an addition, yes.
Q. Is that the only device at the Birmingham Works that in itself is superior to those in use at Essen?
A. In the main, yes.
Q. How long have those sprinkling filters been operating at Birmingham?
A. I cannot say exactly. I should say at least four years.
3958 Q. What is the population served by the disposal plant at Birmingham?
A. I have a note here that in 1908 the sewage plant treated the flow from a sewerage district of about 900,000 people.
Q. Where is the effluent discharged?
A. I fail to have that noted here.
Q. Did you examine the Birmingham system?
A. Several years ago, yes.
Q. Can't you say in a general way where the effluent is discharged, into what water?
A. The sewage of Birmingham is discharged into a stream.
Q. What stream?
A. The name is not noted here. I shall have to look further.

Mr. Riker: Well, I will withdraw the question if you cannot remember.

Q. Have you seen the point of discharge of the effluent at Birmingham?
A. I don't remember seeing its discharge into the stream, no.
Q. I ask you whether you had ever seen the point of discharge?
A. Meaning the point into the stream or the discharge from the plant?
Q. I mean the point in the stream of the discharge?
A. No.
Q. You don't know how far it is from Birmingham?
A. The plant is located some 5 or 6 miles from Birmingham.
Q. Through what cities or towns does the stream flow, after the discharge is made into its water from the disposal works at Birmingham?
A. I can't tell you.
Q. How far from the sea is Birmingham?

(Witness examines papers.)

A. I shall see.
Q. You do not know of your own recollection?
A. No.
Q. Is Birmingham an inland city or is it not?
A. To the best of my recollection Birmingham is an inland city.

Q. Did you examine at any time the waters of the stream into which the effluent was discharged for the purpose of determining what effect that discharge had on the waters?

A. No.

Q. Why not?

A. I did not have opportunity conveniently to do it at the time of my visit.

3959 Q. With reference to the built-up part of the City of Hamburg, where is the disposal plant located?

A. It is located on the water front, not far from the built-up portion of the city.

Q. How far?

A. Adjacent to it.

Q. Well, can't you tell me in miles or parts of miles, or feet or yards?

A. Less than a mile.

Q. How much less than a mile?

A. Well, it is right on the edge of the built-up district of the city along the water front.

Q. And at Dresden, where is the disposal plant located?

A. About two miles below the town; probably about a mile and a half below the town.

Q. Is it open, unoccupied country, from what you define as the town to the disposal works?

A. Yes, distinctly so.

Q. And beyond, what is there?

A. As far as I could see there was open farming country.

Q. Farming country?

A. Yes.

Q. Well, is the country between the disposal plant and the city farming country?

A. Part of it is. It begins to build up within half a mile of the plant up stream I should say.

Q. Where is the plant at Dresden with reference to the built-up part of Dresden?

A. I have just answered that question.

Q. Frankfort then?

A. The plant at Frankfort is located on the opposite side of the river from the main part of the town, and I should say about a mile from it.

Q. Is the opposite side of the river built up at all?

A. Not directly opposite.

Q. Near the plant, how is it with reference to being built up?

A. There are no buildings immediately adjacent to the plant, say not within a third of a mile.

Q. Well outside of that radius of a third of a mile, is it built up?

A. It is not built up compactly.

Q. What character of buildings are they?

3960 A. Chiefly second class suburban residential houses.

Q. Are you familiar with the Newark Meadows?

A. I have been across them.

Q. You did some work in connection with this Passaic Valley Sewerage project, did you not?

A. Yes.

Q. Can you identify or recollect the location of the proposed disposal plant?

A. Not in detail.

Q. Well, in a general way can you?

A. I have never seen the location definitely determined.

Q. Are you familiar with the Newark Meadows?

A. I have passed across them on a train.

Q. Are they built-up to as great an extent as the territory surrounding the Hamburg Disposal plant?

A. No.

Q. Or the Dresden plant?

A. There is not such a big difference there.

Q. Or the Frankfort plant?

A. No.

Q. Or the Birmingham?

A. I don't recollect the character of the surroundings at Birmingham.

Q. Essen. How do they compare with the location of the Essen plant?

A. The Essen plants are more centrally located.

Q. Are you familiar with the plant at Washington, D. C.?

A. No, I don't know just what you refer to.

Q. The disposal plant at Washington, D. C.?

A. No, I am not familiar with it.

Q. You never have seen it, have you?

A. I have seen the sewage pumping station at Washington, but I have not known of the disposal plant there.

Q. Well, is there any screening work there?

A. Yes, there are some bar screens.

Q. Well, that particular work at Washington; how does it compare in location with the location of the Newark Meadows?

A. I should say it was more central.

Q. In your opinion would the nuisance be more serious and more apparent at any one of these plants or all of them than at the proposed Newark plant?

1961 A. What is that question, please?

The stenographer thereupon repeated the question.

A. I think it would not.

Q. You don't think it would be more serious at Washington?

A. Not in accordance with the plants as they exist.

Q. Do you think it would be less or more serious the same operations, at the plant at Hamburg, than they would be at the proposed plant on the Newark Meadows?

A. I think somewhat more so

Q. Same operations at the Frankfort plant, would they be more apparent or more serious in the way of a nuisance than they would be at the proposed plant on the Newark Meadows?

A. If you could have the same conditions existing at Frankfort, as you would have at the Newark Meadows, but the Frankfort plant receiving fresh sewage——

Q. I did not ask you that, Mr. Greeley, the same conditions I am speaking of.

The stenographer thereupon read the question.

The Witness: Somewhat more so.

Q. Why?

A. Because of the somewhat greater proximity to the town.

Q. Do you know how far the proposed plants of the Passaic Valley Sewerage Commissioners are distant from the nearest point of the State of New York?

A. No.

Q. Can't you approximate?

A. No, I cannot.

Q. Would you say it was nearer than 5 miles?

A. I should say so.

Q. How much nearer?

A. I could not say.

Q. Why do you say it is nearer than 5 miles if you cannot form any estimate?

A. That is just my impression.

Q. That is an impression merely. Do you think the odors from the Newark plants will reach the territory of New York?

A. I think they might.

Q. Under what conditions?

A. Under favorable atmospheric conditions.

Q. Describe these favorable atmospheric conditions under which you think that the odors from this disposal plant would reach New York?

3962 A. A wind in the right direction.

Q. What else, is that all?

A. That would be the chief consideration.

Q. Would those conditions differ in any way from the odor carried from Hunter's Point to New Jersey under favorable winds?

A. I am not familiar with the location of Hunter's Point.

Q. You don't know the oil distilleries there?

A. In Bayonne?

Q. Now, I did not ask you about Bayonne; I asked you Hunter's Point; do you know where Hunter's Point is?

A. No, I am not familiar with it.

Q. When did you graduate from Harvard?

A. In 1903.

Q. And you differ in your opinion from the opinion of Mr. Johnson?

A. In certain respects.

Q. Were you under Mr. Johnson's direction during part of your career?

A. Yes.

Q. What screens do you understand are to be used in the Passaic Valley Disposal plant?

A. Mr. Johnson has spoken of them as screens of the Hamburg type.

Q. Is that all you know about it?

A. I have not seen a description any other place.

Q. You have not seen a description anywhere else?

A. Not of that detail, no.

Q. Have you read the stipulation which it contained in Complainants' Exhibit No. 135?

A. Yes.

Q. And does that indicate to you what the screens will be?

A. Just states that they shall be self cleansing mechanical screens, having clear openings of not over 4/10ths of an inch.

Q. Does that describe the Hamburg type or doesn't it.

A. In a general way.

Q. Mr. Greeley, if the effluent as produced by the Passaic Valley Sewerage plant and discharged at Robbins Reef into New York Bay under the conditions described in the stipulation being Com-
1963 plainants' Exhibit No. 135, results in the guaranteed results of this stipulation, will there be any nuisance created in New York Bay?

A. What is that question?

The stenographer thereupon read the question.

The Witness: I think no serious nuisance.

Q. Well, any nuisance?

A. I thing no serious nuisance.

Q. Do you know what a nuisance is?

A. A nuisance is a relative term applied to something that affects the public describing a condition that affects the public deleteriously.

Q. You have qualified your answer by saying that there will be no serious nuisance. What nuisance of any kind, serious or not, in your judgment, will be produced by the effluent as described, which produces the results described in the stipulation which is Complainants' Exhibit No. 135 (Handing witness Exhibit No. 135)?

A. I think that if the stipulations as stated in Complainants' Exhibit No. 135 are fulfilled, that there will be no public or private nuisance created thereby.

Q. Well, what did you intend by your qualification of your answer by serious nuisance?

A. There is stated in the stipulation that there will be practical absence on the surface of New York Bay of any grease or color that might create some slight nuisance.

Q. Yes, but, Mr. Greeley, reading the whole of these guaranteed results and bearing in mind that the stipulation is that there shall be no nuisance in New York Bay, are you willing to say that there will be?

A. Not if the conditions of the stipulation are fulfilled.

Q. Well, then, you don't want to qualify yourself at all do you, by the word "serious"?

A. No.

Q. You wish to withdraw it?

A. Yes.

Q. Is it possible to produce an effluent which will fulfill the results guaranteed in the stipulation, Complainants' Exhibit No. 135 in your opinion?

A. I think that is possible.

Q. In your opinion as an expert in these matters, has dilution anything to do with the safe disposal of sewage?

3064 A. I think it has to do with the disposal of sewage as regards the prevention of a nuisance.

Q. In your opinion can the same amount of sewage of the same quality be more safely discharged, so far as nuisance is concerned, into a large body of water than into a small body of water?

A. That depends upon the uses and environments of the two bodies of water, those conditions being equal the largest body would be the safer into which to discharge it.

Q. I understand you to say that you have not been able to determine from the processes and plants described in the stipulation, Complainants' Exhibit No. 135, just what type of plant will result; am I right in that?

A. Yes.

Q. Therefore you cannot say what the effluent will be, can you?

A. Not in detail, no.

Q. You can't therefore, say what additional appliances or processes might in your opinion be required to produce the effluent which will result as guaranteed in this stipulation?

A. No.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Is it possible to produce the effluent stipulated for in Complainants' Exhibit No. 135 with the plant described in that exhibit?

A. I think not.

Q. Do colloidal matters undergo putrefactive changes?

A. I understand that they do.

Q. Do these putrefactive odors occasion nuisance?

A. They do.

Q. Is there any provision in Complainants' Exhibit No. 135 for the elimination of the colloidal matters that will be likely to occasion that nuisance?

A. No.

Q. Do pathogenic germs that occasion disease such as typhoid fever—would you regard those as a nuisance in a sewage effluent?

A. Yes.

Q. Is there any provision in Complainants' Exhibit No. 135 to eliminate the pathogenic germs from the effluent?

A. No.

Q. If an effluent such as is guaranteed or stipulated for in its

results as set forth in Complainants' Exhibit No. 135 was
3965 produced, would it occasion any greater nuisance in Newark Bay than it would in New York Bay?

A. No.

Q. Does the age of sewage affect its sedimentation?

A. Yes.

Q. In what way?

A. In a general way, the older the sewage, the less the efficiency of sedimentation.

Q. How would the sewages of Hamburg or Birmingham compare in that respect with the proposed amount of sewage to be delivered at the Newark Meadows in the Passaic Valley Trunk Sewer project?

A. They would be fresher.

Q. You mentioned sprinkling filters. Will you describe what you mean by the term sprinkling filters?

A. A sprinkler filter is a bed of broken stone about 6 feet deep, the stones being proportioned in varying sizes from 1 inch to 2½ inches in size over which the sewage is sprinkled and allowed to trickle over the stones and through the interstices into under-drains, provided at the bottom of the stone beds.

Q. Is that an advanced mode of purifying the sewage effluent?

A. Yes.

Q. Is there any such provision for the purification of the sewage effluent to be produced as set forth in Complainants' Exhibit No. 135?

A. No.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. Now, Mr. Greeley, in what respect does the discharge of pathogenic germs into the waters of New York Bay constitute a nuisance in your opinion?

A. Well, I think it is deleterious to the public.

Q. In what way?

A. In that it creates a possibility of increasing the death rate.

Q. That is what you define as a nuisance, is it?

A. I think that could be classed as a nuisance.

Q. And does the production of a nuisance in that way depend in any way, in your opinion, on the conditions of the water into which pathogenic germs may be discharged?

A. Yes.

Q. If the waters are already polluted by the crude sewage of a population of four or five millions of inhabitants, does that have any effect upon your judgment as to whether an addition
3966 of pathogenic germs will be a nuisance or not?

A. No.

Q. It has no effect?

A. No.

Q. Do you think that where a nuisance already exists, it would

exist, would it not, from the discharge of crude sewage from four or five millions of inhabitants into the waters of New York Bay?

A. I think so.

Q. Where such a nuisance exists, you think the discharge of pathogenic germs constitutes a nuisance?

A. Yes.

Q. Well, as compared with the discharge of pathogenic germs indirectly through the waters of the Passaic River, Newark Bay and the Kill van Kull into New York Bay, do you think the discharge of pathogenic germs from this sewer will constitute any further nuisance?

A. As a comparison between the transmission of the germs by way of the Passaic River, Newark Bay, the Kill von Kull and the trunk sewer, I think there would be a greater nuisance as relates to New York Bay by way of the trunk sewer.

Q. Why?

A. I think that the germs would proceed under more favorable conditions to the outlet in New York Bay.

Q. Why?

A. I think that there would be greater natural conditions tending to destroy the germs in the passage through the river and the Newark Bay and the Kill von Kull.

Q. What are those natural conditions in your opinion?

A. Trade wastes in the river; the temperature of the river water as being lower than the temperature of the sewage. I mention those as a few.

Q. You are bearing in mind, are you, that the trade wastes are to be discharged through the sewer?

A. It is my understanding that all of the trade wastes are not to be taken through the sewer.

Q. It is your understanding, is it? That is what you base your answer on with reference to the pathogenic germs?

A. In part, yes.

Q. Well, what would be the difference in the temperatures of the river waters which discharge directly through the Kill von
3967 Kull into New York Bay as compared with the temperatures of the sewage when discharged at Robbins Reef?

A. The sewage in the River water and the Newark Bay would in my judgment be less.

Q. The temperature would be lower?

A. Lower.

Q. How do you reach that conclusion?

A. That is my opinion.

Q. Well, what is it based on?

A. On observations of the temperature of sewage and the temperature of flowing streams.

Q. Observation of temperature of the streams into which sewage is discharged directly as compared with the temperature of sewage flowing through a trunk sewer. You made those comparisons, did you?

A. Yes.

Q. Where?

A. At Hamburg, and I found the temperature of the sewage coming out of the main trunk sewer, which was comparatively fresh sewage to be 68.9 degrees Fahrenheit and the temperature of the Elbe water to be 66.2 under summer conditions.

Q. That is 3 degrees difference, about?

A. Yes, I would expect under winter conditions that it would be very different.

Q. And would you expect any difference from the sewage being what you have termed old as to temperature?

A. Yes.

Q. Would it be higher or lower?

A. I would expect it would be higher.

Q. If it is old?

A. Yes.

Q. How much higher?

A. I can't say in precise terms.

Q. What effect would the carrying of it through a deep tunnel have upon the temperature in your opinion; increasing the temperature or decreasing the temperature of the sewage?

A. I should say that if it was fresh sewage it would tend to decrease—I should say if it was any sewage, it would tend to decrease the temperature slightly.

Q. Now, Mr. Greeley, you were asked on redirect whether an effluent as described in stipulation, Complainants' Exhibit No. 135, which produced the results guaranteed in New York, would also produce the same results in Newark Bay. Is it your opinion that an
3968 effluent when discharged at Robbins Reef at the depth it is stipulated and in the way it is stipulated, and resulting in the absence of visible suspended particles in New York Bay, would also result in an absence of visible suspended particles if discharged into Newark Bay?

A. Yes.

Q. The depth of the water has nothing to do with that?

A. No.

Q. The depth of the water would have no effect upon it, in your opinion?

A. No, not in the positive way stated.

Q. Well, do you think that if there was an absence of visible suspended particles resulting from the discharge of the effluent in New York Bay at Robbins Reef that necessarily the same effluent discharged in Newark Bay would result in the absence of suspended particles in Newark Bay?

A. Yes.

Q. The quantity of the water has nothing to do with this result in your opinion?

A. Not as between these two places.

Q. Why not?

A. Because the difference is not sufficient.

Q. Well, what is the difference?

A. I can't tell you that in precise figures.

Q. Well, what difference would be sufficient to make a difference in the results in your opinion?

A. Well, it would be a very great difference?

Q. Well, how great?

A. The discharge into a small river compared with the discharge into New York Bay.

Q. That would be sufficient in your judgment, would it, to account for a difference in this result?

A. Yes, sir, to account for a difference.

Q. What is the volume of water in Newark Bay?

A. I am not familiar with those figures.

Q. What is the volume of water in New York Bay?

A. I am not familiar with those figures.

Q. What are the depths of the water in Newark Bay?

A. I am not familiar with that.

Q. How deep would it be possible to discharge an effluent
3969 into Newark Bay.

A. I am not familiar with that.

Q. How can you testify then, that the effluent which will produce the guaranteed results in New York Bay will produce the same results in Newark Bay, if you do not know the elements of the problem?

A. I can express my opinion based on such observations and connections with the work as I have had.

Q. And having such value as your opinion may have under those conditions?

A. Yes.

Q. Now, an effluent which will result in the absence in New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in it, will result, in your opinion, in the same way if discharged into Newark Bay?

A. Yes.

Q. Does the body of water in your opinion have anything to do with this result?

A. As comparing Newark Bay and New York Bay and the character of effluent stipulated, I should say not.

Q. Have you in answer to this question and in the mean while and since the last questions were put to you, obtained any further knowledge as to the quantity of water in Newark Bay?

A. No.

Q. And in New York Bay?

A. No.

Q. And are the quantities of water, the relative quantities of water in these two bodies of any importance in determining and giving a value to your opinion?

A. I think so.

Q. You don't know any thing about the relative quantities then?

A. Not in precise figures.

Q. Well, in a general way what do you know about them?

A. I think in a general way that there is not sufficient difference to make the discharge different in the two bodies.

Q. Upon what do you base that and what do you intend by — in a general way?

A. I mean that I am not familiar with the precise quantities of water in Newark Bay and New York Bay, but that I have observed them, so that in a general way in my opinion, the effluent as stipulated will not create differences, if discharged into the two bodies.

3970 Q. Now, what is the effluent which is stipulated?

A. Stipulated in Complainants' Exhibit No. 135.

Q. What is the effluent as stipulated in Complainants' Exhibit No. 135? Describe it?

A. I refer to the conditions to be produced rather than to the effluent, because the effluent is described by the conditions which it will produce or which it will not produce.

Q. Well with the effluent described in your opinion?

A. Well, the conditions which it will not produce are stated.

Q. And your answers to the question on your redirect examination was that the conditions produced in New York Bay would be produced in Newark Bay?

A. Yes, sir, if the stipulation——

Q. (Interrupting.) That it would be the same effluent?

A. I did not intend to make that statement. If the effluent conformed with the conditions required of it in New York Bay, it could be discharged with similar effects in Newark Bay.

Q. But the same effluent that produced the results guaranteed in New York Bay if discharged into Newark Bay would produce the same results?

A. Yes, sir.

Q. And you would say, would you, that an effluent which in a body of water of the size and capacity of New York Bay would result in the practical absence of odors due to the putrefaction of organic matters when discharged into a body of water of the size and capacity of Newark Bay, would result in the absence of odors due to the putrefaction of organic matters?

A. Yes, the condition of the effluent being the same or similar.

Q. The effluent being the same?

A. Yes, sir.

Q. The quantity of water has nothing to do with that, has it?

A. The quantity of water as relates to these two bodies, in my opinion, has nothing to do with this.

Q. Does the quantity of water have any effect upon the production of odors from an effluent, the same effluent discharged into it?

A. Yes.

3971 Q. Well, will you tell me in multiples or in any other way at what point the difference in the volume of water is important?

A. That depends so largely on so many conditions that I cannot give a definite statement in numbers.

Q. Well, are you assuming the same effluent?

A. Under what conditions ?

Q. The same effluent in all respects. If you will assume that. Now, what other conditions do you want to assume for your comparison?

A. Will you read that original question again, please?

The stenographer thereupon read the question referred to as follows:

Q. Well, will you tell me in multiples or in any other way at what point the difference in the volume of water is important?

The Witness: I should say that if the discharge of this similar effluent into water of 75 times its volume, that above that ration there would be very little difference in its effect on the body of water.

Q. That is to say if the bodies were less than 1 to 75?

A. Yes.

Q. There would be very little effect?

A. No, more. That is if the body of water contained more—was a greater proportion than 75 times.

Q. You mean to say that discharge into a body of water which would be represented by 1 might not safely be made, whereas it could safely be made into a body of water representing 75 or over?

A. That was not exactly what I meant. What I meant was that if discharged into a body of water of which it was 1/175th in volume, and if it was then discharged into a volume of water of which it was, say 1/100th, the resulting condition would not be different.

Q. Well, Mr. Greeley, assume that an effluent is being discharged into the waters of New York Bay of just that sufficient clarity and purified to that degree, that there will be there an absence of odors due to the putrefaction of organic matters contained in the effluent; do you think that effluent will be discharged into Newark Bay and that there would then be no odors in Newark Bay due to the putrefaction of organic matters?

A. Yes.

3872 Q. Well, into a body of water half the capacity of Newark Bay, do you think it would be safe to discharge an effluent that would produce the results guaranteed in New York Bay?

A. I don't know as to that.

Q. Well, do you know as a matter of fact the difference in the results in Newark Bay and New York Bay?

A. That is my opinion based on what I know of the two waters. I stated that I did not know the precise figures.

Q. Well, what is the depth of New York Bay?

A. That is variable. I understand that the effluent is to be discharged into 40 feet of water so that at parts of New York Bay, the depth of water would be 40 feet.

Q. Well, it is greater in other parts?

A. That I am uncertain about definitely.

Q. Well, in multiples, what do you understand to be the difference in capacity between New York Bay and Newark Bay?

A. I have not got that.

Q. Well, has that any influence upon your opinion as to the

results of discharging the same effluent into these two bodies of water?

A. Not the exact figures.

Q. Well, the general figures in a general way? Can't you give me some idea of what the difference in capacity between these two bodies of water is?

A. No.

Q. Well, if the difference is 1,000 to 1, would that have any effect upon your judgment as to the safety of discharging the same effluent into these two bodies of water?

A. Yes.

Q. Do you know whether the difference is as great as 1,000 to 1?

A. I have not the figures to state that.

Q. Well, then, how can you express any opinion in regard to this problem, Mr. Greeley?

A. I have an opinion as to the effect on the two waters.

Q. An effluent which in the discharge into the waters of New York Bay at Robbins Reef will produce no grease or color due to its discharge; do you think when discharged into Newark Bay, it will necessarily have the same result?

A. Yes, I do.

3973 Q. Why?

A. Because I think that if no grease were evident on New York Bay that the removal would be sufficient to make the same conditions hold in Newark Bay.

Q. The quantity of water has nothing to do with that problem, then?

A. Not as between the two bodies of water.

Q. I will ask you whether the quantity of water theoretically, without reference to these two bodies of water in your opinion would have any effect in this respect?

A. As to the general discharge of sewage into water, it has an effect.

Q. I am asking as to the production of color, grease or color, whether the quantity of water has anything to do with the production of grease and color from an effluent discharged into it?

A. Yes.

Q. Well, at what point, where does it begin to have an influence?

A. That depends on so many local conditions that I cannot give a precise answer.

Q. Now, assume that the effluent is identical, and assume that the waters are similar in quality, will a discharge of an effluent which in a body represented by 1 in volume and producing color and grease when discharged into a body of water represented by 1,000 produce color and grease?

A. I think it would.

Q. Where is the point at which there will be a difference in result?

A. I can't say definitely.

Q. You said that there would be, you remember, in your opinion?

A. Yes.

Q. Well, would it be in a ratio of 1 to 5,000?
A. I cannot say definitely as to that.
Q. Would it be 1 to 1,000,000?
A. There would undoubtedly be a difference between those two dilutions.
Q. What is the ratio between the water of Newark Bay and that of New York Bay in quantity?
A. I do not know.
Q. Is it 1 to 1,000,000; is it as little as 1 to 1,000,000?
A. No.
3974 Q. How do you know?
A. From my observation of the two bodies of water.
Q. Your observation has been confined to the surface, has it not?
A. Yes.
Q. You would not place the importance of the volume at a ratio below 1 to 1,000,000?
A. Not in precise terms.
Q. Well, I did not ask you to put it in precise terms, but I asked you would you place it lower than 1,000,000, anywhere lower than 1 to 1,000,000?
A. I should say that it was less than 1 to 1,000,000.
Q. Would it be less than 1 to 500,000?
A. I should say that it would.
Q. Yes; as a matter of fact do you know where it would be?
A. Not in precise terms.
Q. Now, an effluent which discharged into New York Bay under conditions described in the stipulation which is Complainants' Exhibit No. 135, and occasions no public or private nuisance in your opinion would that effluent when discharged into Newark Bay necessarily produce no private or public nuisance?
A. I think not.
Q. Has the volume of water in the two bodies described anything to do with this result?
A. Not to the relation of New York Bay and Newark Bay.
Q. And is your answer to this question based upon any other or more precise information than you have obtained by observing the surface of these two bodies of water?
A. No.
Q. It is not based upon any acquired knowledge of the actual volume of the water of the two bodies?
A. Not which I have in mind in precise terms at the present time.
Q. Well, what have you in mind; have you anything in mind as to the relative volumes of these two bodies of water?
A. Not in precise terms.
Q. Well, what have you, if anything, in mind, except your observation of the surfaces?
A. No other precise features.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

3975 Q. Mr. Greeley is Newark Bay and New York Bay subject to the same tidal phenomena and the refreshing and other influences of that phenomena?

A. Not exactly the same.

Q. If an effluent will produce no public or private nuisance, will it make any difference as to what body of water it is discharged into?

A. No.

Q. Will grease rise to the surface no matter how large or how small the body of water into which an effluent containing it will be discharged?

A. Yes.

Q. What was the ratio of dilution beyond which you stated it made no difference to the relative volume of the bodies of the dilutent waters?

A. As I recollect it was between ratios of 1 to 75 and 1 to 125.

Q. And beyond that the relative capacities of the dilu-ent waters mattered little for an effluent such as was guaranteed in its results in Complainants' Exhibit No. 135?

A. Yes.

Recross-examination by Mr. Riker:

Q. Mr. Greeley, one question. You said now, on your examination that an effluent which resulted in no public or private nuisance in New York Bay, would result in no public or private nuisance if discharged anywhere into any body of water; did I understand you correctly to say that?

A. No, I did not intend to say that?

Q. Well, what did you intend to say?

A. Read that question please.

The stenographer thereupon read the question.

Q. Having had that read to you, do you mean to stand by that as your answer?

A. Yes.

Q. That an effluent which would produce no public or private nuisance in one body of water, no matter how large, could be safely discharged into any body of water, however small?

A. As I understand it, that is a somewhat different question. I think the quantity of water does have an effect.

Redirect examination by Mr. O'Sullivan:

3976 Q. Can you produce an effluent that is good enough to drink; that will be potable?

A. Not potable to the general public.

Q. Can you distill the sewage effluent so as to get absolutely pure water from it?

A. You can.

Q. Would such an effuent create a public or a private nuisance?

A. I should say not.

Mr. O'Sullivan: That is all.

Adjourned to May 29th, 1913, at 10:30 A. M.

Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, May 29th, 1913—10:30 A. M.

Before James D. Maher, Esq., Commissioner.

Appearances: William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants;
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

3977 Met pursuant to adjournment.

EMIL KUICHLING, a witness in behalf of the Complainants, recalled, in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Mr. Kuichling, have you testified previously in this suit?
A. I have sir.
Q. Have you been present and heard all the testimony offered by the defendants in this suit at the hearings held in Newark, New Jersey?
A. I have.
Q. Did you take notes of the testimony of each witness called on the presentation of the Defendants' testimony in this suit?
A. I did, sir.
Q. Did you subject to study and analyses the statements made by these witnesses and did you compare them with the records of your own experience and the scientific experiences of recognized scientists?
A. I did.
Q. Have you studied the location of the proposed outlets of the sewage of the Passaic Valley District near Robbins Reef Light in Upper New York Bay, and if so, will you describe the results you have reached in those studies?

Mr. Riker: The question is objected to on the ground that it is not directed to any testimony of the defence, and is not rebuttal.
The Commissioner: Note the objection of Counsel for the Defendants.

A. According to the plans of the Passaic Valley Sewerage Commission, the sewage of the Passaic Valley District is to be discharged through a series of 150 outlets which are located within an irregular area of 2.35 acres. This area is about 505 feet long in a south-

easterly direction and 205 feet wide in a southeasterly direction. The northwest corner of this area is 1455 feet due east and 641 feet due south of Robbins Reef Light, and its southwest corner is 1166 feet due east and 1047 feet due south of said Light.

3978 A straight line joining these two corners is about 505 feet long, and has a course or bearing of north 36 degrees 20 minutes east. The center of gravity of the said 150 outlets is about 33 feet northwesterly of the middle of the straight line just described, or is 1286 feet due east and 814 feet due south of said light; it is 1522 feet distant from said light on a course south 57 degrees and 40 minutes east. At low tide the depth of water in this area is mostly about 40 feet and it increases to 50 feet at the eastern edge near which the otherwise level bottom begins to slope downward. Robbins Reef Light is located about 2270 feet or 0.43 miles, due north of that portion of the boundary line between the States of New York and New Jersey which runs westerly from Upper New York Bay through the Kill Van Kull, and about 3430 feet or 0.65 mile, northwesterly from that portion of said boundary line which runs northeasterly through Upper New York Bay from the Kill Van Kull to the mouth of the Hudson River. Said Light is also 4.0 miles south of Battery Point in Manhattan Borough, 0.86 mile north of the Municipal Ferry House at St. George on Staten Island or Richmond Borough, 1.95 miles west of the shore at Bay Ridge in Brooklyn Borough, and 1.27 miles east of Constable Point in Bayonne, New Jersey. These latter figures are derived by scale measurements on a chart of New York Harbor published by the United States Coast and Geodetic Survey in February 1910, being Complainants' Exhibit Nos. 171 and 171A, and differ slightly from the corresponding figures given in my previous testimony, which figures were derived from the map of New York and vicinity published by the United States Geological Survey in 1909.

Q. Mr. Kuichling, have you studied the tidal currents in Upper New York Bay in the vicinity of Robbins Reef Light, and if so, state how much the sewage of the Passaic Valley District will be diluted with Bay water on being discharged in calm weather?

Mr. Riker: Same objection.

3979 The Commissioner: Note the objection.

A. To comprehend the results of the discharge of 360,000,000 gallons of sewage per day, or 557 cubic feet per second, at the locality just described by me, it is necessary to study very closely the topography or conformation of the bottom of the entire Upper New York Bay, as shown by complainants' Exhibit No. 126, and also to keep in mind the observations that have been made on the peculiarities of the tidal currents at said locality. The tendency of the sewage to rise to the surface by reason of its smaller specific gravity than that of the salt water into which it is discharged is likewise a highly important factor. To facilitate such study, I have drawn from the aforesaid chart of the United States Coast & Geodetic Survey, and herewith submit a set of five cross sections through Upper New York

Bay and also a profile of the bottom of said Bay along the line of the deepest points.

(Witness hands counsel paper.)

Q. What do these charts that you have just handed me portray or represent, Mr. Kuichling?

A. The drawing represents a series of five cross sections of Upper New York Bay and also a profile of the bottom of Upper New York Bay taken along the line of deepest water. Cross Section No. 1, as marked on the drawing, is taken 500 feet south of the mouths of the Hudson and East Rivers, beginning on the left at the bulkhead line of Jersey City, New Jersey, a short distance south of the ferry house of the Central Railroad of New Jersey, and running thence on a course south 69 degrees 27 minutes east to the bulkhead line of Brooklyn near the foot of Reveen Street. This section is practically through the northern end of Upper New York Bay.

Mr. O'Sullivan: I offer this chart or map showing the cross sections of New York Upper Bay and this profile, prepared by this witness, in evidence, and ask that it be marked Complainants' Exhibit No. 205.

Mr. Riker: The offer is objected to on the ground that it is
3980 not rebuttal and that the paper offered has not been properly proved, so as to become evidence in the case.

The Commissioner: Note the objection of Counsel for the Defendants.

Received in evidence and marked Complainants' Exhibit No. 205.

Q. Directing your attention now to Complainants' Exhibit No. 205, Mr. Kuichling, I ask you what the cross section marked No. 2 represents and where it was taken or made?

Mr. Riker: The question is objected to on the ground that it does not call for any answer in rebuttal of any testimony offered for the defense.

The Commissioner: Note the objection of Counsel for the Defendants.

A. Cross section No. 2 is taken at 6500 feet or 1.23 miles south of the mouth of the Hudson River, beginning on the left at the shore line of Jersey City, in the district known as Communipaw, about 1700 feet north of the long pier of the Lehigh Valley Railroad, and running thence on a course south 55 degrees 18 minutes east passing about 1076 feet northeast of Bedloe's Island and 400 feet southwest of the foot of Governors Island, to the bulkhead line of Brooklyn at the foot of Partition Street or the point called Red Hook.

Cross Section No. 3 is taken at 19,900 feet or 3.77 miles south of the mouth of the Hudson River, beginning on the left at the shore line of Bayonne, New Jersey, 6590 ft. south of the new long terminal pier of the Pennsylvania Railroad and running thence on a course south 66 degrees 44 minutes east through Robbins Reef Light and the northern part of the area on which the proposed outlets of the sewage of the Passaic Valley District are located, to the bulkhead line

of Brooklyn at the foot of 63rd Street, which is 2890 feet northerly of the pier at Bay Ridge.

3981 Cross section No. 4 is taken at 29,800 feet, or 5.65 miles south of the mouth of the Hudson River, beginning on the left at the shore line of Stapleton, Staten Island, or Borough of Richmond, near the foot of Canal Street, or about 2.13 miles southerly of Robbins Reef Light, and 1.25 miles south of the ferry house at St. George; and running thence on a course North 82 degrees 10 minutes east to the shore line of Brooklyn at the foot of 83rd Street, which is 3270 feet south of the aforesaid pier at Bay Ridge and 1.48 miles north of Fort Lafayette at the Narrows.

Cross section No. 5 is taken through the Narrows on a line through Fort Wadsworth on the left and Forts Lafayette and Hamilton on the right. This line is 38,850 feet or 7.35 miles south of the mouth of the Hudson River, and is the southern end of Upper New York Bay. It should be mentioned that all the aforesaid distances of these cross sections from the mouth of the Hudson River are measured along the curved line of greatest depth of water, and that if measured in a straight line, the distance from the middle of cross section No. 1 to the middle of cross section No. 5 would be 6.49 miles. The cross sections shown on Exhibit No. 205 are drawn as if looking north from the point where each section was taken.

The profile of the bottom of Upper New York Bay, shown on Complainants' Exhibit No. 205 is taken along the line of greatest depth of water indicated on the said Chart of New York Harbor published by the United States Coast and Geodetic Survey in February 1910, which chart has been marked Complainants' Exhibit Nos. 171 and 171A. The longitudinal distances inscribed on this profile are measured along the line of deepest water from cross section No. 1 southerly to cross section No. 5 aforesaid, and beyond these limits the distances northerly up the Hudson River and southerly down Lower New York Bay can be determined readily from the engraved scale. An examination of this profile shows that the bottom is very irregular, the depth at low water ranging from 46 feet to 116 feet, with numerous elevations and depressions whereby the general directions of the tidal currents are modified materially.

3982 Cross section No. 3 deserves particular attention as it passes through Robbins Reef Light and also nearly through the center of the said group of 150 sewage outlets. As will be seen by reference to the drawing in Complainants' Exhibit 205, the entire cross sectional area of the water is divided naturally into three parts. The first part extends from the Bayonne shore to Robbins Reef Light, a distance of 2.414 miles, or 12,746 feet, has a maximum depth of 11.5 feet at low water, and an area of 17.48 per cent. of the total area. The second part extends from Robbins Reef Light to the middle of a long bar near the Brooklyn shore, has a width of 1.408 miles, or 7,432 feet, a maximum depth of 66 feet at low water and an area of 62.64 per cent. or a little more than ⅝ths of the total area. The third part extends from said bar to the Brooklyn shore, has a width of 0.76 mile, or 4036 feet, a maximum depth of 38 feet at low water, and an area of 19.88 per cent of the total area, which latter

is 380,466 square feet. The entire width of the section is 24,214 feet, or 4.58 miles, and the average depth at low water is 15.71 feet. The average depths at low water of the said three parts are respectively 5.22, 32.07 and 18.74 feet, and the corresponding sectional areas are respectively 66,496, 238,336 and 75,634 square feet.

It will also be seen from this exhibit that the said group of sewage outlets is located in the second part of the said section near Robbins Reef Light, and on a bottom sloping to the deepest channel. This channel is about 2350 feet wide at a depth of 40 feet, and 3190 feet wide at a depth of 30 feet below low water surface. From a point about one mile north of Robbins Reef Light, the course of this deep channel is a curve, convex to the west, extending southerly to the Narrows, but its depth is by no means uniform, as is shown in the following table which is derived from scale measurements to points of deepest soundings shown on Complainants' Exhibit Nos. 171 and 171-A.

3983 *Table Showing Profile of Bottom of Upper New York Bay Along the Line of Greatest Depth Below Low Water Surface, Beginning at the Mouth of the Hudson River Opposite Battery Point in Borough of Manhattan, and Ending 0.9¼ Mile South of the Narrows or Line from Fort Wadsworth to Fort Lafayette.*

Point No.	Distance from mouth of Hudson river.		Greatest depth below low water surface.	Point No.	Distance from mouth of Hudson river.		Greatest depth below low water surface.
	Feet.	*Miles*	*Feet.*		*Feet.*	*Miles.*	*Feet.*
0.....	0.0	0.0	50	21.....	22,600	4.28	50
1.....	700	0.13	50	†22.....	23,900	4.53	61
2.....	1,700	0.32	60	23.....	25,200	4.77	61
3.....	3,000	0.57	87	24.....	26,700	5.06	57
4.....	3,700	0.70	93	25.....	28,400	5.38	55
5.....	4,900	0.92	86	26.....	29,400	5.56	53
6.....	5,900	1.12	83	27.....	30,600	5.80	58
7.....	7,400	1.40	65	28.....	31,300	5.93	63
8.....	8,400	1.59	74	29.....	31,900	6.05	69
9.....	9,600	1.81	60	30.....	32,700	6.19	76
10.....	10,900	2.07	56	31.....	33,500	6.34	77
11.....	12,700	2.41	56	32.....	34,300	6.50	78
12.....	13,500	2.55	53	33.....	35,300	6.68	75
13.....	14,500	2.74	59	34.....	37,000	7.00	80
14.....	15,800	3.00	60	35.....	38,000	7.19	90
15.....	17,200	3.25	70	‡36.....	38,800	7.36	94
16.....	18,500	3.50	75	37.....	39,200	7.42	96
17.....	19,300	3.66	71	38.....	40,400	7.64	101
*18.....	19,900	3.77	66	39.....	41,700	7.90	107
19.....	20,500	3.88	60	40.....	42,900	8.12	109
20.....	21,500	4.07	46	41.....	43,900	8.30	116

NOTE.—* Denotes point of intersection with section line through Robbins Reef Light.

† Denotes point of intersection with deep channel of Kill Van Kull.

3984 ‡ Denotes point of intersection with line from Fort Wadsworth to Fort Lafayette.

The foregoing table shows that in the distance of 4.53 miles from the mouth of the Hudson River to Kill Van Kull, the maximum channel depth ranges from 93 to 46 feet, with an average of 64.2 feet; and that in the distance of 2.83 miles from Kill Van Kull to the Narrows at Fort Lafayette, it ranges from 55 to 94 feet, with an average of 70.2 feet; also that in the entire distance of 7.36 miles from the mouth of the Hudson River to the Narrows at Fort Lafayette, it ranges from 46 to 94 feet, with an average of 66.0 feet. It may also be stated that the width of the Upper Bay varies greatly, as follows:—just below Battery Point, 1.91 miles; from Red Hook to Communipaw, 2.74 miles; from Bayonne through Robbins Reef Light to northern part of Bay Ridge, Brooklyn, 4.59 miles; from Tomkinsville, Staten Island to Bay Ridge, 1.94 miles; from Stapleton, Staten Island, to southern part of Bay Ridge, 1.78 miles; at Narrows, 0.99 mile. The area of the Upper Bay is 20.74 square miles; its length in a straight line from Battery Point to the Narrows is 7.00 miles, and its average width is thus 2.96 miles.

Besides the aforesaid great variations in both width and depth of Upper New York Bay, further complications are introduced by the flow from the Hudson and East Rivers and the Kill Van Kull, or Newark Bay.

In my previous testimony I called attention to the surface currents and drifts that take place in Upper New York Bay, and to the fact that the strongest currents are found in the principal channel which is characterized by the greatest depth of water, and which I have more fully described a few minutes ago. The sewage of the Passaic Valley District discharged into this principal channel in the
3985 manner previously described, will be carried along by the strong tidal currents without much diffusion after rising to the surface, and will form a relatively narrow belt, field or area, which will oscillate with the tides from 8 to 10 miles from Robbins Reef Light up and down the Bay in calm weather. The numerous experiments made with floats by the United States Coast and Geodetic Survey and the Metropolitan Sewerage Commission of New York indicate clearly that a floating particle of matter placed in the principal channel near Robbins Reef Light, will thus oscillate back and forth for at least two or three tidal periods, or from 25 to 38 hours, before it remains permanently in the Lower Bay, or below the Narrows; also that under less favorable conditions, it will return to a point above the Narrows during a much greater number of tidal periods and hours. On the average such a particle will oscillate back and forth in the Upper Bay about three days in calm weather.

What I have just said about a floating particle in the principal channel of Upper New York Bay, can also be applied to the sewage proposed to be discharged near Robbins Reef Light, but in this case the gradual diffusion of the sewage into the salt water of the Bay must be taken into account. I stated previously that the 150 sewage outlets planned by the Passaic Valley Sewerage Commission are located in an area of about 2¾ acres, which is about 505 feet long and 205 feet wide on the average, on the west side of the said principal channel of the Upper Bay, where the water is not less

than 40 feet deep at low tide. With allowance for initial diffusion the width of the area may be considered to be 300 feet and its length 600 feet, so that if the water over said area were stationary its volume would be 7,200,000 cubic feet. Into this volume the sewage will flow at the rate of 360,000,000 gallons per day or 557 cubic feet per second. If the water were stationary for one hour at the turn of the tide, it would thus be mixed with about 2,000,000 cubic feet of sewage. It is claimed in Defendants' Exhibit No. 5, however, that the water of the Bay in said locality is never wholly quiescent at the turn of the tide, but that the lower two thirds of said volume has an average motion of about one
3986 quarter foot per second, while the upper third is temporarily stationary. This is due to the fact that the currents do not reverse simultaneously in all parts of a cross section of the channel.

Accepting these figures for the under-current at slack water or turn of tide as correct, and that the duration of slack water is 30 minutes, then the prism of water that would be polluted by one half hour's discharge of sewage, or 1,000,000 cubic feet, is 300 feet x 1050 feet x 40 feet = 12,600,000 cubic feet, so that if the Bay water were clean the sewage would be diluted 12.6 fold. This makes a ratio of one part of sewage to 12.6 parts of clean water. At the end of the said half hour, however, this same volume will return and be dosed a second time with sewage, whereby the dilution would become only half as much, or about 6.3 fold, or 1 part of sewage to 6.3 parts of clean water. A similar action occurs at the next turn of tide, and so on for from 3 to 6 or more tidal periods, until the volume of water that has been dosed repeatedly with sewage remains permanently below the Narrows, or becomes purified by slow natural processes. It is therefore obvious that in calm weather the sewage will not become mingled with the entire tidal volume of water passing through the Bay, but will be mixed with only a very small fraction of the tidal flow in each tidal period.

Mr. H. De B. Parsons has testified in Complainants' Exhibit No. 91 in this suit, that the total average ebb flow through the Narrows is 12,040,000,000 cubic feet during a period of 6.7 lunar hours, or 6.935 solar hours, and that the total average flood flow through the Narrows is 10,780,000,000 cubic feet during a period of 5.3 lunar hours, or 5.486 solar hours. By reducing to the average rate of flow per second, these figures become respectively 482,200 and 545,800 cubic feet per second, while the proposed rate of sewage discharge from the Passaic Valley Sewer District in 1940 is 557 cubic feet per second; but a comparison between these figures cannot be made to ascertain the extent to which the said sewage will be diluted with Bay water, for the reasons previously given
3987 by me. An approximation to the average rate of dilution during a tidal period may be obtained by estimating the mean velocity of the tidal current at the locality under consideration, and applying this velocity to the aforesaid prism of Bay water lying above the said sewage outlets. Assuming such velocity at 1.0 feet per second, and the sectional area at 300 feet x 40 feet = 12,000 quare feet, the initial dilution will become $\frac{12000}{557} = 21.5$

fold, but this will quickly be reduced by repeated dosing as the water oscillates back and forth over the sewage outlets.

The subject of the dilution of the sewage deserved particular attention because most of the witnesses for the defense have referred to the large volume of tidal flow through the Narrows from and into Upper New York Bay, and compared it with the relatively small volume of sewage proposed to be discharged during the tidal periods. They have also assumed tacitly that the mixture of the sewage with the entire volume of flowing tidal water takes place very rapidly or instantaneously, whereas the process of diffusion of sewage in brackish water is actually accomplished very slowly, as shown by the observation of sewage fields in salty waters. It can be presumed that with these erroneous premises as to diffusion, they easily reached the conclusion that the dilution of the sewage would always be extremely great, and hence that no nuisance in Upper New York Bay would ever result from the proposed discharge of the sewage of the Passaic Valley District. The true facts to be borne in mind are: 1. That the sewage diffuses very slowly in the brackish water; 2. That the sewage tends to float on the top of the brackish water; 3. That the experiments made with colored fresh water discharged into the brackish Bay water in the vicinity of Robbins Reef Light tend to establish the two preceding facts; 4. That the same volume of Bay water which comes into immediate contact with the said sewage at any moment of time is repeatedly exposed to such contact in consequence of the oscillatory tidal motion of the water over the sewage outlets; and 5, that such oscillation may range from 5 to 12 or more before the initially
3988 polluted body of water remains permanently below the Narrows.

Q. Have you studied the details of Mr. G. A. Johnson's experiments made with dyed water on November 19th, 1907, and if so, state with what results?

Mr. Riker: The question is objected to as not being in rebuttal of any specific testimony offered on the part of the defense.

The Commissioner: Note the objection of Counsel for Defendants.

A. In his testimony given on February 13, 1913, for the Defendants for the Defendants in this suit, Mr. George A. Johnson described a series of four experiments with dyed fresh water which he discharged on November 19, 1907, at depths of 10, 20, 30 and 40 feet into the waters of Upper New York Bay at a point about ⅝ mile northeast of Robbins Reef Light. He stated that the discharges at depths of 10 and 20 feet appeared soon on the surface of the Bay, while those at depths of 30 and 40 feet did not appear on the surface. From this he expressed the conclusion (on page 3982 of the testimony) that if the freshwater sewage of the Passaic Valley District were discharged in the manner proposed at a depth of not less than 404 feet below the surface of the Bay, it would undergo sufficiently complete diffusion in the waters so as not to rise to the surface in objectionable quantity, if at all, and rarely

invisible quantities. In my opinion this conclusion is not warranted by the data submitted by Mr. Johnson. The point where the said experiments of November 19, 1907, were made is not near the point which has been selected for the discharge of the sewage of the Passaic Valley District, but is more than ⅝ mile north of the latter. Furthermore, in each experiment the dyed fresh water was discharged vertically downward through a 6 inch pipe having a sectional area of 0.200 square feet, with velocities of from 9 to 10 feet per second and at rates of from 1.8 to 2.0 cubic feet per second, during brief periods of time ranging from only 6 to 16 minutes. On the other hand, the said sewage is proposed to be discharged vertically upwards and continuously from 150
3989 conical annular outlets, each 24 inches in diameter and 2 inches wide with a sectional area of 1.13 square feet, a velocity of 3.27 feet per second, and a delivery of 3.71 cubic feet per second when the total daily discharge of sewage is 360,000,000 gallons, or 557 cubic feet per second. A little reflection surfices to prove that the conditions of the said short experiments are not comparable with those that will ensue if the continual discharge of sewage is permitted. The tidal currents at the locality are constantly changing in both direction and intensity, and are at times stronger at the bottom than at the surface. They are also affected by the wind and the seasonal discharges of the Hudson River. In November 1907, the flow of this River attained its maximum for that month, and was more than twice its average flow during November from 1891 to 1908 inclusive, and nearly eight times its minimum flow in November, 1908; so that when said experiments were made the salinity of the water of the Bay was considerably lower than usual in this month, thereby making the specific gravity of the dyed water more nearly equal to that of the Bay water and retarding its tendency to rise to the surface of the brackish water. The greater flow of the river in said month also tended to prolong the duration of ebb currents, and to modify the action of the under-run currents appreciably. The record of Mr. Johnson's experiments on November 19, 1907, should also have included a statement as to the condition of the weather on that day. I have examined the official records of the United States Weather Bureau for said day in the City of New York, and find therefrom that it was foggy from 5 A. M. to 9 A. M. and cloudy during most of the remainder of the day; that from 12 M to 4 P. M. the wind was blowing from the northwest with a velocity of from 11 to 16 miles per hour, which was sufficient to have caused the surface water in the Bay to be rough and to drift southeasterly towards the Brooklyn shore; that the temperature of the air from 12 M to 4 P. M. ranged from 50 degrees Fahrenheit to 54 degrees Fahren-
3990 heit, and that on the preceding day it reached a minimum of 39 degrees Fahrenheit, also that from 11:40 A. M. of November 18 to 4 A. M. of November 19, 0.79 inch of rain fell. The temperature of the water on said day was not mentioned by Mr. Johnson, but in November 1909, it was found to range at Robbins Reef Light from 54 degrees Fahrenheit to 46 degrees Fahrenheit, as given in the testimony of Mr. H. De B. Parsons in

this suit. As the dyed water used by Mr. Johnson was prepared on November 18 and remained exposed to a low temperature over night, it may be inferred that on November 19 it was somewhat cooler than the Bay water, whereby its specific gravity approaches that of the latter, and its tendency to rise through the latter was correspondingly reduced on being discharged.

The various physical conditions on November 19, 1907, which I have just described, were in my opinion such as to render it very difficult to perform delicate experiments in the Bay at Robbins Reef, and to obtain therefrom results that would be sufficiently trustworthy to warrant the broad conclusion expressed by Mr. Johnson. A further reason for objecting to said conclusion is that the latter does not appear to be founded on a thorough knowledge of the complex tidal currents in the vicinity of Robbins Reef Light. The data given by Mr. Johnson relating to the direction and intensity of the currents below the surface of the water during the time of his said experiments on November 19, 1907, are very incomplete and indefinite. They represent merely the observations of the pull and general direction of the upper part of a thick cord attached to a deeply submerged receptacle for taking samples of water. They indicate only that the bottom velocity is strong or slight when the surface current is strong or slight and in the same direction; and they differ in this respect from the far more accurate observations made by the United States Coast Survey in 1858 and 1859, cited by Mr. Johnson on page 3977 of the testimony, which show that at Robbins Reef Light slack water at the
3991 bottom of the main deep channel occurred two or three hours before low slack water occurred at the surface, whereas Mr. Johnson's data on page 3978 tend to show that the motion of the water at the bottom stops at about the same time that it stops on the surface.

I have also examined closely the published Reports of the Superintendent of the United States Coast Survey for the year 1858 and 1859, but was unable to find in Appendix 8 thereof anything but a general list of items of work performed by this Department. On page 38 of the said Report for 1858, the following statement is made: "At a station between Governor's and Bedloe's Islands, the currents were observed at the surface and at 17, 42 and 68 feet depth, respectively, the depth of water at the station being 80 feet. The flood drift, or current, at 42 feet and still more at 68 feet, greatly exceeds that at the surface in velocity and duration, while the ebb drift at 68 feet is very feeble, that at 42 feet being still considerable. During the course of the tide, the axis of the drift or line of greatest movement, changes its place considerably, rising or sinking." In Appendix No. 28 of the said Report, pp. 204-207, Mr. Henry Mitchell describes briefly the tidal currents in the East River and Upper New York Bay, the essential features being set forth as follows: "We have ascertained that, instead of uniform graduation of velocities from surface to bottom, there often occurs in deep channels a counter-drift, or even distinct streams,

at different depths. These singular movements were ascertained to belong to certain localities only in New York Harbor, where they assume sometimes the forms of immense rotatory movements in vertical planes. At some of our stations phenomena of this character never fail to repeat themselves daily, on the recurrence of certain tidal phases, while at others the wind enters in as an element and varies the conditions. At certain stations we found that when the surface current is opposed by strong winds, the axis of the stream sinks, and the water pours on below the retarded
3992 stratum. * * * From the most hasty consideration of our results, it may be seen that without a knowledge of these sub-currents, structures however simple, placed in New York Harbor, may be productive of the most disastrous consequences, by controlling in a degree the future movements of the shoals, or by causing new deposits."

A somewhat longer description of the tidal currents in New York Harbor is given by Mr. Henry Mitchell in Appendix No. 15, pp. 301-311 of the Report of the Superintendent of the United States Coast and Geodetic Survey for 1887. In this document sketches of the under-run at the last stage of flood and ebb are given, showing the positions of inclined strata of water of different density or salinity in different parts of the harbor from the Lower Bay to the Tappan Sea. It also contains a number of diagrams showing how the velocity varies from the surface to the bottom at a number of points, but none of these are in the vicinity of Robbins Reef Light. It also appears from my examinations that Mr. Mitchell's original report on the subject was never published in full by the Superintendent of the United States Coast and Geodetic Survey, and that general references thereto appear only in the Reports of 1858, 1859, 1863 and 1887.

The quotations I have just made indicate that the tidal currents in Upper New York Bay are very complex in character, and the fact that a full report on them has not yet been issued by the United States Coast and Geodetic Survey can be regarded as evidence that they are still under study. Some of the difficulties of the problem will appear by examining the profile of the bottom of this bay shown on Complainants' Exhibit No. 205. The most significant feature of this profile is the prominence or peak marked A somewhat south of Robbins Reef Light. At low water the depth is here only 46 feet, whereas 3,200 feet northerly the depth is 75 feet at the point marked B, and 3,000 feet southerly it is 60 feet at the point marked
C. The effect of this peak A is manifestly to deflect the
3993 lowest stratum of water polluted by the sewage near Robbins Reef Light upwards during ebb, thus tending to bring it to the surface in the vicinity of the Kill Van Kull, or the Point C; while during flood tide, the lowest stratum of heavier salt water entering from the lower Bay is also deflected upwards, and tends to reach the surface in the vicinity of the point B, where it will gradually settle down through the lighter brackish water unless its weight is reduced by admixture with the said sewage. In both cases the polluted water will tend to remain at the surface.

Referring again to the aforesaid experiments on November 19, 1907, Mr. Johnson stated that the Government had predicted that low water would occur at Robbins Reef Light at 12:45 P. M. on that day. I have been unable to find this particular prediction in the "Tide Tables" published by the United States Coast and Geodetic Survey, but found in said tables for 1907 that low water would occur at Governors Island at 1.57 P. M. on said day. I also found on a diagram of tidal periods and currents for New York Harbor on page 481 of Tide Tables for 1907 and page 489 of Tide Tables for 1912, published by the United States Coast and Geodetic Survey, that low water at Robbins Reef Light occurs normally about 12 minutes before it occurs at Governors Island, so that on November 19, 1907, low water should have been expected at Robbins Reef Light, at 1:45 P. M. or one hour after the time stated by Mr. Johnson. In order to ascertain the actual time that low water occurred on said day, I examined the chart or automatic mechanical record for November 19, 1907, of the standard tide gage maintained at the Battery by the Dock Department of New York City. These records are preserved in the office of said Department on Pier A, Hudson River, and I found that low water on said day was indicated at about 2:25 P. M. The distance from the Battery south to Governors Island is only 0.71 miles, and the difference in time between the occurrence of low water at the two places has been found to be very small or practically inappreciable hence it can be concluded
3994 that on said day low water at Robbins Reef Light actually occurred about 2:10 P. M.

It is also shown by the aforesaid diagram in Tide Tables for 1907 and 1912, that slack low water at Robbins Reef Light normally occurs 2.5 hours after low water at Governors Island. This reckoning would make slack low water at Robbins Reef Light on November 19, 1907, occur at about 4.50 P. M. whereas, according to Mr. Johnson's data, it occurred at 2:30 P. M. A similar discrepancy is found in the time of occurrence of slack water, or stoppage of motion, at the bottom, if the said hour (2:30 P. M.) given by Mr. Johnson for slack low water at the surface is correct. According to the observations of the United States Coast Survey cited by Mr. Johnson on page 3977 of the testimony, slack water at the bottom occurs 2 or 3 hours before it occurs on the surface, so that on said day there would have been no motion at the bottom at from 11:30 A. M. to 12:30 P. M. whereas Mr. Johnson states that there was a strong bottom current in a southerly direction at 1:00 and 1:10 P. M., and that slack water at the bottom occurred between 1.40 and 2:40 P. M. These incongruities lead to the alternative inferences that either some errors in regard to time were made on November 19, 1907, or that the tidal currents on the surface and bottom at Robbins Reef Light had not been studied closely by Mr. Johnson at the time that he drew his conclusion as to the improbability of any of the sewage of the Passaic Valley District rising to the surface if discharged at a depth of 40 feet in the vicinity of Robbins Reef Light. This particular feature is the essential element of the project under consideration, and it is very evident that

in view of the great complexity of the tidal currents in New York Harbor, as set forth by the United States Coast and Geodetic Survey, many other experiments lasting much longer than two hours should have been made at the contemplated point of discharging an enormous volume of sewage before expressing the vital conclusion mentioned.

Q. In your opinion will offensive odors be developed in
3995 the vicinity of Robbins Reef Light if the sewage of the Passaic Valley District is discharged in the manner proposed by the Passaic Valley Sewerage Commission?

Mr. Riker: Same objection as not being rebuttal and not being directed to any specific testimony offered on behalf of the defense, being matters already testified to by this witness in his main case.

The Commissioner: Note the objection of Counsel for the Defendants.

A. In view of the great length of the proposed Passaic Valley trunk sewer and outlet tunnel, and the long time that must elapse between the production of the sewage and trade wastes at their point of origin and their final discharge into Upper New York Bay near Robbins Reef Light, there can be no doubt as to the offensiveness of the odors from the proposed effluent as it will be discharged into the Bay in warm weather. No provision for deodorizing this effluent appears to have been made. From many observations in American cities, the temperature of the sewage in summer reaches and exceeds 70 degrees Fahranheit, whereby fermentation becomes very active, and as the time of flow from point of origin to the Bay is from 8 to 16 hours in the case of the sewage under consideration, the liquid will certainly acquire a strongly offensive odor.

It must be remembered that salty or brackish water does not absorb and retain gases and volatile substances to the same extent as fresh water, and that when malodorous sewage is mixed with sea water the offensive odors are quickly liberated and seem to be aggravated in intensity. I have noticed this peculiarity at many sewer outlets into salt waters and have made special experiments with samples of the same foul sewage placed in quart jars containing sea water and fresh water separately. In every instance the odor from the jar filled with sea water soon became much stronger and more offensive than that from the jar filled with fresh water. This took place long before the mixtures began to ferment actively, and
in warm weather the odor from the mixture with sea water
3996 intensified greatly within 24 hours. The same action has also been observed recently by the various experts who investigated the expediency of building a dam across the Charles River near Craigie Bridge in Boston, Massachusetts, as set forth in the elaborate Report of the Committee published in 1903, and also by Professors W. E. Adeney and E. A. Letts in Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, London, 1908.

In the said Report of the Committee on the Charles River Dam, (Boston, 1903) Mr. H. W. Clark, Chemist of the Massachusetts

State Board of Health, states on pages 271 and 272 that as salt water holds less oxygen in solution than an equal volume of fresh water, the latter can receive more pollution, and that the odors from mixtures of salt water and sewage grew worse with time. He also states that the mud flats or bottoms of a salt water basin give off much more offensive odors than the mud bottoms of a fresh water basin. On page 291 he writes that there is the constant tendency for the precipitation of the organic matter or sewage to occur in salt water, and hence for the concentration of this matter in the form of putrefying sludge deposits; and on page 280 he mentions that the action of such sludge in exhausting dissolved oxygen from the water is far more intense than that of mud, since "one-tenth as much by weight of dried sewage sludge as of the muds used in these experiments, exhausts oxygen under similar conditions as provided by many tests."

In the same investigation the biologist, Dr. G. W. Field, found from his observations and experiments that sewage in fresh water was less offensive than in an equal volume of salt or brackish water. Uniform salinity cannot be maintained in a salt water basin, and sudden changes of salinity are fatal to many low forms of aquatic life by which the reduction or transformation of sewage matters is effected. On page 316 he states that the introduction of salt water into a fresh water basin should be avoided, as the plasmolysis
3997 resulting from the contact of the salt water with the delicate fresh water organisms will probably cause their death. All of these expert investigations were carefully reviewed by the engineer of the Committee, Mr. John R. Freeman, who adds on page 81 that "a marked difference is noted in the odors arising from the manholes of the Boston main drainage and Metropolitan sewers to which some proportion of salt water has been admitted, in comparison with the manholes of the common sewers that receive no salt water," the inference being clearly that the odors from the former set of man-holes are worse or stronger than those from the latter. It may also be noted that in his recent book on "Sewage Disposal" New York, 1912, Mr. George W. Fuller, of New York City, commends these investigations as being the best on the subject that have yet been undertaken.

In the aforesaid Appendix VI of the Fifth Report of the Royal Commission on Sewage Disposal, Professors Adeney and Letts state on page 437 that "there seems to be a wide-spread impression that the odors from over-polluted sea water are more offensive than those from over-polluted fresh water. This impression is probably well founded, since sulphides, and possibly organic sulphur compounds, are formed in sea water, when over-polluted, by the reduction of its sulphates." This peculiar reduction is discussed in detail on page 120 of said volume, and is attributed to a specific anærobic organism called "microspira or spirillum desulphuricans," which occurs abundantly in sewage during July, August and September. Sulphuretted hydrogen is produced in this action (p. 122) because the combustion (or oxidation) of the organic matter supplies the energy necessary for reducing sulphates to sulphides; consequently there

should be a definite relation between the amount of carbonic anhydride (or carbon dioxide) and sulphuretted hydrogen evolved, the former deriving its oxygen from the sulphate reduced. Thus in a culture medium containing no other organic matter than sodium lactate, the eventual chemical change must be such as to yield two molecules of carbonic anhydride, either free or
3998 combined for every molecule of sulpuretted hydrogen formed.

The researches of Van Delden and Beyerink indicate that the bulk of the sulphuretted hydrogen occurring in both foul sewage and certain mud banks, owes its origin rather to sulphates than to albuminoid bodies, but they did not investigate experimentally the important rôle played by the ferrous sulphide which is chiefly in evidence in foul deposits. The action of this sulphide was recently investigated by Mr. J. L. McKee, as stated in said Appendix, pages 122-125, and the experiments showed that it was readily decomposed by carbonic acid with liberation of enough sulphuretted hydrogen to cause a serious nuisance. It was also found that ferrous sulphide is decomposed by fatty acids, such as butyric acid, with copious evolution of sulphuretted hydrogen.

In regard to the exact nature of the objectionable odors of sewage and its products of decomposition, comparatively little appears to be definitely known. These odors are associated alike with gases, substances in solution and solids. An excellent discussion of them is given on pages 86 to 99 of Mr. George W. Fuller's aforesaid book on "Sewage Disposal," in which it is stated that while sulphuretted hydrogen has had the reputation of being the most offensive product, yet the correctness of this is doubtful. Indol, skatol, cadaverin, mercaptan, phosphine and some other compounds are likewise found in both fresh and septic sewage, and are all considered much more repulsive than pure sulphuretted hydrogen. Indol and skatol are always found in fresh feces, and show themselves at times in sewers and sewage disposal works. With the exception of sulphuretted hydrogen, all of the substances mentioned are found in sewage only in a soluble non-gaseous state, and make themselves felt by volatilization or evaporation. The gaseous products or sewage decomposition are hydrogen, nitrogen, methane (CH_4), carbonic acid (CO_2), ammonia (NH_3), phosphine (PH_3), and sulphuretted hydrogen (H_2S). It may also be added that odors emanate from solutions of gases and solids far below the point of saturation.

3999 In the second edition of Lafar's "Manual of Technical Mycology" (Jena, 1906), Volume 3, page 85, the subject of the putrefaction of protein is ably discussed by Drs. Hahn and Spieckermann. It is there stated that when air (or oxygen) is partially or wholly excluded from dead vegetable or animal matter, the process called putrefaction ensues and is accompanied by the plentiful evolution of offensive odors. In the case of animal matter, proteid and gelatinous or albuminous substances predominate, and carbohydrates occupy a secondary position. The former class of substances, however, contain much sulphur and nitrogen, and hence their putrefaction is marked by the formation of basic compounds

of nitrogen and offensive volatile compounds of sulphur. In the case of vegetable matter, on the other hand, carbohydrates usually predominate to great extent, and its putrefaction involves the formation of certain acids and gases whose odors are much less pungent and repulsive; but when the vegetable matter approximates animal matter in composition, such as grains or seeds rich in portein, its putrefaction proceeds in nearly the same manner as that of animal matter.

From the foregoing facts I reach the conclusion that in calm and warm weather, an extensive dilution or admixture of the sewage with the tidal water of Upper New York Bay will not take place; also that this sewage will have an offensive odor and that this odor will be liberated soon after such admixture and will create an unmistakable nuisance in the vicinity of Robbins Reef Light; and that such odor nuisance will be carried by light winds to the shores of Upper New York Bay. In reaching this conclusion I take into account the further fact that the waters of Upper New York Bay can never become pure and saturated with dissolved oxygen, owing to the unavoidable pollution brought into them by the washings of the densely populated tributary watershed during heavy rainfalls, even if all the sewage proper of this watershed were treated in the manner proposed by the Passaic Valley Sewerage Commission and discharged elsewhere.

4000 From a practical point of view, it cannot be expected that the waters of Upper New York Bay will ever attain the same degree of purity that they had 50 years ago; and therefore, in considering the disposal of sewage by dilution, it must be borne in mind that in this particular case the diluting brackish water of the Bay is widely different in quality from that of large unpolluted rivers and great lakes. It may also be added that the testimony offered by the defendants in this suit does not contain any data from which any other conclusions than those just expressed by me can be reached.

Q. In your opinion, will the proposed effluent of the sewage of the Passaic Valley District contain visible particles of suspended matter, and will such particles be visible in the waters of Upper New York Bay in the vicinity of Robbins Reef Light?

Mr. Riker: Same objection as to the last question.

The Commissioner: Note the objection of Counsel for the defendants.

A. The matters carried in suspension in sewage are generally grouped into three classes, viz: 1, the lighter solids that always float on the surface of the liquid; 2, the solids that have approximately the same specific gravity as the liquid and are distributed throughout its entire volume without settling to the bottom while the liquid is moving at velocities of more than 1.5 feet per second; and 3, the solids that are much heavier than water, and which are carried along on the bottom of the sewer by the current, but do not mingle extensively with the bulk of the liquid. The second class embraces the semi-liquid substances known as colloidal mat-

ters, as well as the finely-divided solids or minute particles which will not settle within a period of several hours to the bottom of a tank wherein the sewage is kept in an approximately quiescent state. As the term "colloidal matter" is often used loosely in speaking of sewage, it will be of interest to describe such matter
4001 more definitely, especially as it is frequently classed with the matters found in solution. Thus is a paper on the subject by Dr. J. H. Johnson, in the Journal of the Royal Sanitary Institute of England, Vol. 27, (1906), page 55, it is stated that about one half of the dissolved organic matter in sewage is in colloidal solution; and in another paper on page 433 of the same volume, Messrs. Purvis and Coleman refer to certain colloidal matter in sewage as being highly complex nitrogenous compounds, which remained held in solution at the end of 8 weeks of observation.

Substances are usually regarded as colloidal which swell up into a gelatinous mass when water is added to them. Gelatine, glue, starch, paste, agar, etc. are such colloids and exhibit their character when their temperature is reduced. Soaps and emulsions of fat and oils are also typical colloids. Many mineral compounds possess the same property, as when sodium silicate is mixed with hydrochloric acid, whereby a voluminous gelatinous precipitate of silicic acid is formed. Similar precipitates are the hydroxides of iron and aluminum, certain acids of tin and wolfram, sulphide of arsenic, and numerous others which can be removed from dilute aqueous solutions by dialysis. The very fine silt carried along by large rivers also contains much colloidal silica in combination with potash, nitrogen and phosphoric acid derived from the water.

The protoplasm of plants and animals consists essentially of albuminous matter. Many albuminous substances of animal origin, such as white of egg and blood serum, form colloidal solutions in fresh water, while others like the globulins become soluble on adding sodium chloride, or in sea water, and still others, such as casein and certain artificial alkaline albuminates, require the addition of basic alkaline salts. All of these colloidal solutions will be retained on a dialyzing membrane, and can be precipitated as gelatinous masses under various conditions of coagulation or peptisation. Vegetable albumens are formed in all plants and are also found in the seeds.
They resemble animal albumens by being coagulated by
4002 heat and various chemical reagents; they are also digested and show the same chemical relations and general composition, but it has not yet been proved that these two albumens are identical.

By the processes of putrefaction and fermentation, albumens are reduced to fatty acids and odorous combinations like phenyl-propionic acid, skatol-acetic acid, phenols, indol and skatol, and various ptomaines or toxins are also produced thereby. Proteids are first attacked by transient aërobic changes, such as ammonia and urea; next to anaërobic organisms, and lastly by oxygen and nitrification. The chemical composition of these albumens shows that they contain from 50 to 55 per cent. carbon, 15 to 19 per cent. nitrogen, 19 to 24 per cent. oxygen, 6.6 to 7.3 per cent. hydrogen,

0.4 to 5.0 per cent. sulphur, with small amounts of phosphorus and iron. Glue-like substances are the products of the incipient oxidation and reduction of albumen in the bodies of animals, and are the chief component of connective tissue, gristle and cartilage. They differ from albumen by containing less carbon and being solid instead of liquid. Fats are reduced much more slowly than the proteids or albumens, and in sewage they must emulsify before they can be acted on by bacteria. Experience has demonstrated that sewage containing much fatty matter is far more difficult to treat than that in which the suspended matter consists mostly of proteids and carbohydrates. The fats are generally compounds of alcohol, glycerol and fatty acids such as stearic, palmitic and oleic acid, and the most important of these compounds are called stearine, palmitine, oleine and butyrine. Most animal fats are mixtures of two or more of these substances in different proportions, and they consist of carbon, hydrogen and oxygen.

Carbohydrates embrace a large number of substances which are represented by starches, sugars, cellulose and wood fibre. The sugars are perfectly soluble in water, and are changed by fermentation into alcohol. The starches and some kinds of cellulose are converted into sugars by weak acids and certain ferments, but other
4663 kinds of cellulose and wood fibre are highly resistant and undergo decomposition by ferments in sewage tanks very slowly.

Most colloidal matter is developed in the economy of mankind and domestic animals, in the form of excretions and degenerations of cellular structures, especially those of the epithelial type. These cells become swollen by a translucent gelatinous semi-liquid substance, and are thrown off, whereupon they fuse together and form colloid masses. The gelatinous mucin which is normally secreted by the epithelial cells of the mucous membranes and glands is also colloidal, and in certain diseases of the elementary tract this mucoid matter infiltrates into the surrounding tissues forming the so-called "colloid cancer."

Colloidal matter is characteristic of the widely diversified groups of textile fibres. It has a wide range of cohesion, elasticity, and extensibility and in the form of cellulose and some other substances it maintains these characteristics throughout a cycle of transformations whereby it is brought into soluble plastic form, in which condition it can be drawn out into continous filaments of indefinite length. The artificial silks or lustra celluloses are produced in this way, and have obtained a position as staple textiles.

The animal fibres are composed of nitrogenous colloids which are typically represented by albumens, fibrines and gelatines. They are of highly complex chemical constitution, and their characteristics have been only generally investigated. The vegetable fibre substances are celluloses and derivations thereof which are also typical colloids. The broad distinction between these two groups of fibres is chiefly evident in their relation to alkalis. The animal group is attacked and finally dissolved by alkalis under conditions of action by no means severe, whereas the celluloses and vegetable fibres are

extraordinarily resistant to such action. In general it may be said that all animal fibres will be dissolved in a 10 per cent. solution of caustic potash, and that wool is distinguished from silk by its relative resistance of sulphuric acid. The cold concentrated acid
4004 rapidly dissolves silk and vegetable fibres, but attacks wool slowly.

The animal fibres are comparatively few in number, but of great industrial importance. They occur in detached units and of varying length; sheep's wool has lengths up to 36 inches and horse hair up to 24 inches, while silks have a length of hundreds of yards. The vegetable fibres are extremely numerous and of very diversified characteristics. They are individualized units only in the case of seed hairs, of which cotton is the most important. With this exception they are elaborated as more or less complex aggregates such as the *bast* tissues that furnish such staples as flax, hemp, ramie and jute. In the process preparatory to spinning, the fibre aggregates are more or less subdivided. In *this* groups are included the woods that furnish pulps of various grades, and which are resolved by acid and alkaline chemical means.

The organic matter in sewage consists chiefly of urea, proteids or albumens, carbohydrates, fats and soaps, all of which are more or less soluble in fresh water and colloidal in character, as already mentioned. These substances are also putrescible, and when caused to settle in a sewage tank the process of putrefaction will soon begin, or will progress rapidly if it has started previously while flowing in the sewer. From what I have said in the foregoing, it is evident that many industrial wastes which are usually discharged into the sewers of a city contain much putrescible organic matter of colloidal character, and long experience has shown that a large proportion of it is difficult to treat in a satisfactory manner. This is particularly true of the wastes from tanneries, abattoirs, sugar works and cellulose factories.

Most of the recent technical literature on the subject of sewage purification recognizes the necessity of securing the most complete removal of the suspended solid and colloidal matters before applying the final oxidation processes to the effluent containing the
4005 fully dissolved organic substances; and some authors insist that clarification is essentially the result of purely physical operations, and that bacteria play only a subsidiary part in the purification process. Hitherto little seems to be known about the best means of arresting and precipitating or depositing the colloidal substances which constitute so large a proportion of the soluble organic matter. In 1905 Dr. G. J. Fowler and Mr. E. Arden recorded in the "Journal of the Society of Chemical Industry," Volume 25 page 483, certain observations they had made about organic matters in emulsion or colloidal form in the sewage of Manchester, England. They showed that such matter was about 60 per cent. of the oxidizable matter, and about 76 per cent. of the albuminoid nitrogen; also that in domestic sewage the percentage was somewhat higher. Their experiments indicated that the proportion of colloidal matter in the effluent from the Manchester septic tank was

about the same as in the septic sewage. In the filtered sewage 50 per cent. of its contents of albuminoid nitrogen came from matter in colloidal solution, and in the case of the filtered effluent from the septic tank about 47.5 per cent. was in such solution. They also found that if the said tank effluent was allowed to stand, large quantities of organic matter would settle on the bottom, and that deposits would form even when this effluent was first filtered through paper. It therefore follows that the quantity of soluble colloidal substance present in the sewage in pseudo-solution or emulsion represents potentially suspended matter and should be treated as such.

In reporting sewage analyses, it has been customary to regard all matter that passes through ordinary filter paper as being in true solution, but it is a fact that the liquid issuing from such a filter is usually quite turbid and contains much finely-divided solid matter as well as much colloidal matter. Even the relatively pure waters that are filtered for domestic use through beds of sand contain considerable colloidal matter that soon forms a thick, slimy
4006 coating on the surface of these beds; and in the treatment of sedimented sewage by intermittent application to beds of broken stone or other similar material, all the surfaces of this material quickly becomes coated with colloidal slime, which often increases in thickness to such extent as to cause partial clogging. Similarly, when sewage is treated in a septic tank, the sides and bottom soon become coated with precipitates of colloids that appear at first in small globular masses, and subsequently agglutinate into a continuous sheet. It has been claimed by some investigators that the formation of these organic precipitates is accelerated by the process of putrefaction, and that the effluent from such a septic tank passes much more freely through filter paper; but this was not found to be the case at Manchester, as previously mentioned. In regard to the physical nature of a colloidal solution, various opinions have been expressed by different investigators. Some picture such a solution as consisting of extremely minute particles in suspension, thus making a heterogen-ous system of insoluble matter in a solid phase with the solvent in liquid phase. Others consider that a colloidal substance becomes hydratized or swells in volume by the absorption of water, and eventually becomes entirely dissolved, also that this hydration is always accompanied by a development of heat, and that the water thus absorbed is held comparatively strongly in combination. Another set of investigators maintain that only a portion of the absorbed water is held strongly combined, the remainer being held loosely, while still others regard a jelly as having a cellular structure like a honey-comb, or else with the cells outlined by filaments instead of continuous thin partitions of solid or semi-solid matter. Lastly, it has been held that a colloidal solution consists of a mixture of two similar solutions, one containing little and the other much water, and having different viscosities, whereby a surface tention is developed between them upon which the formation of the emulsion depends.

4007 Colloidal solutions are known to be extremely sensitive to changes of temperature, and also to vary in character with

quiescence or agitation. The mechanical coagulation of such a solution seems to require the presence of a freely exposed surface of some kind whereby a change of surface tension is induced. By the addition of electrolytes, most colloids will be precipitated from their solutions in the same manner as finely divided suspended matter is precipitated. Such precipitation of colloids has been regarded as being due to the abstraction of water therefrom by salts or electrolytes; but in general the coagulating action of a salt will depend on its ionic or electrical relations to the substance. The stability of a colloid is considered to be the greater in proportion as its particles are smaller and as their electrical charges are greater. True colloids like albumen can be protected from precipitation by adding stable colloids to them.

Aside from the various colloidal substances, it is also known that a large proportion of the finely-divided solid matter suspended in sewage will settle only after the lapse of many hours during which the liquid is kept in a quiescent condition. Recent investigations of these slowly sedimentable particles which are usually found in the effluents from sewage tanks in sufficient quantity to cause strong turbidity, have proved that they consist of putrescible organic matter, and that they in conjunction with the colloidal matter, make up the greater part of the putrescibility of such effluents, as determined by the methylene blue test. Both of these kinds of matter cannot be removed by screens nor by sedimentation in open tanks during a period of one or two hours, and the quantity of such matters in suspension depends on the quality, condition and treatment of the sewage before arriving at the tanks. Dr. Arthur Lederer, chemist and bacteriologist of the Sewage Testing Station of Chicago, found in a number of his tests with relatively fresh sewage that after 4 hours' sedimentation the liquid still retained in suspension
4008 from 54 to 67 per cent. of the original amount of suspended matter, and that in his other tests it was always more than 30 per cent. Similar results were also obtained by Mr. C. B. Hoover, chemist of the Columbus Sewage Works, and still larger figures have been observed in the effluents from certain septic tanks in regular operation in warm weather. As all of the finely divided solid matter in suspension and many of the colloidal substances are visible to the eye, I am of the opinion that particles of suspended matter will be plainly visible in the effluent proposed to be discharged near Robbins Reef Light from the Passaic Valley Sewerage works. These suspended particles will be plainly visible in the waters of upper New York Bay after such discharge.

Q. Have you made an exhaustive study of the amount of suspended matter in the sewage of cities, that will deposit in settling tanks within periods of one hour and 1½ hours; and if so, state the percentage of such matter that will settle within these periods?

Mr. Riker: Same objection as to the last question.

The Commissioner: Note the objection of Counsel for the Defendants.

A. By reason of the septic character of the sewage, its long course of transit, the action of the pumps and the additional fermenta-

tion that must inevitably occur in the sedimentation tanks in warm weather, the solid matters which are carried in suspension in the liquid will be extensively comminuted. This reduction of size renders their sedimentation more difficult, and a much smaller quantity of such matter will be deposited in the tanks than if the sewage were fresh and flowed quietly by gravity into them. Mr. George A. Johnson has testified for the defendants in this suit that in his opinion about 35 per cent. of the total amount of suspended matter would be deposited in the proposed sedimentation tanks during a period of from 1 to 1½ hours, and he based this opinion on the results which he obtained with fresh sewage at Columbus,
4009 Ohio, in a tank with a period of detention therein of 1.3 hours. These results indicated a removal of 34 per cent. of the suspended matter, as given on page 78 of Mr. Johnson's report published in 1905. This shows that 66 percent. of the suspended matter escaped with the tank effluent, and it is evident to every one who is familiar with sedimented sewage that most of these particles of matter will be plainly visible in the liquid. It should also be noted that the effect of sedimentation is by no means uniform. It varies greatly with the nature and size of the particles, as well as with the quietness and temperature of the liquid. At high temperatures sedimentation proceeds much more slowly than at lower temperatures in perfectly quiescent and clean water. When the sewage reaches a temperature of 60 degrees Fahrenheit or more, gases are evolved copiously by the fermentation of the organic matter in the sedimentation tank. The ascent of these gas bubbles through the liquid causes vertical currents which are opposed to the slowly descending particles and the bubbles themselves become attached thereto, thus making them rise and form a scum-like floating stratum which escapes with the effluent. In cold weather, fermentation is much less active, the evolution of gas is greatly reduced, and the liquid remains quiet, so that the effluent becomes much clearer. The difficulty in sedimentation is usually with the small particles of organic matter whose specific gravity is nearly the same as that of water, and the smaller their size the longer the time required for them to settle on the bottom of the tank. In warm weather three or four hours are found necessary to accomplish the same degree of sedimentation that is attained in one or two hours in cold weather. The stipulation for the discharge of said sewage that was made by the Secretary of War, provides for a period of sedimentation of not more than 1½ hours. In my opinion this period of time is inadequate in warm weather to secure the removal of even 30 per cent. of the suspended matter in the sewage that will enter the proposed settling tanks. The reasons for this opinion have already
4010 been given; and supplementing my previous answer, I believe that a countless number of particles of matter contained in the effluent from said tanks will be plainly visible in the water of the Bay near Robbins Reef Light.

Q. Have you made an exhaustive study of the amount of suspended matter in the sewage of cities, that will be arrested by or

caught on screens having apertures or openings ½ inch in size; and if so, state whether such amount is as large as 10 or 15 per cent?

Mr. Riker: Same objection as to the last question.

The Commissioner: Same as before.

A. Mr. George A. Johnson testified for the defendants in this suit that a screen having clear apertures or openings ½ inch in width would remove or arrest about 15 per cent. of the total suspended matter in the sewage of the Passaic Valley District. The data on which this testimony was based were not given, and I have examined many official reports of sewage treatment published in this country and abroad, in the hope of finding confirmatory results, but without success. In his experiments with the sewage of Columbus, Ohio, in 1904, Mr. Johnson caused the sewage to pass in succession through two diamond-mesh wire cloth screens, of which the first had clear openings of ½ inch, and the second of $\frac{3}{8}$th inch, as set forth in his Columbus Report, 1905, page 59, bottom. The wet matter thus caught on these two screens is stated on page 22 of said Report to have had a volume of 0.17 cubic yard, or 4.59 cubic feet, and to have weighed about 300 lbs., on the average, from every million gallons of sewage. An analysis of this wet matter is not given in said Report; but from analyses of similar matter taken from sewage screens elsewhere it is found that from 75 to 90 per cent. of the weight of the wet screenings is water, the remainder being dry solid matter. The crude sewage of Columbus contained about 200 parts of dry suspended matter per million by weight, the averages ranging from 196 to 242, as given on page 77 of said Report. Now, if the wet screenings at Columbus contained 20 per cent. of dry solid matter by weight, then the said two screens removed on the average $\frac{300}{5} = 60$ lbs. of such matter per million gallons, or 8,350,000 pounds of sewage; hence the rate of removal was $\frac{60}{8.35} = 7.18$ parts per million by weight. But the sewage contained from 196 to 242 parts of suspended matter per million by weight, and therefore the said two screens actually removed only from 2.9 to 3.7 per cent. of the total suspended matter in said sewage. This result is very different from the 15 per cent. removal claimed by Mr. Johnson for the ½ inch screen proposed for the sewage of the Passaic Valley District. Another case is afforded by the experience gained in the treatment of the sewage of Reading, Pennsylvania, as set forth in the Official Report of Mr. E. B. Ulrich, City Engineer, for the year 1912. For the last 4 months of that year the sewage was screened exclusively through plates having round perforations ½ inch in diameter, and the quantity of wet matter thus removed was on the average 2.925 cubic feet per million gallons of sewage. The weight of this wet matter is given at about 60 lbs. per cubic foot by Mr. E. S. Chase, chemist of the Reading sewage works, in a paper published in "Engineering News" of Au-

4011

gust 22, 1912, pages 340 to 345, and its content of water at 79.6 per cent. With these data, the dry solid matter in the said volume of screenings is 35.8 pounds per million gallons or 8,350,000 pounds of sewage, or at the rate of 4.29 parts per million by weight. The total amount of suspended matter in the crude sewage is not given directly, but from the figures relating to sludge removed in the different stages of treatment, I have computed that it must have been about 150 parts of dry solids per million by weight on the average; hence the said screening with ½ inch perforations removed only about 2.8 per cent. of the suspended matter. Numerous instances of similar nature might also be cited to show the strong improbability that a screen with ½ inch openings is able to remove 15 per cent., or even 10 per cent. of the total suspended matter in ordinary municipal sewage; and hence I believe that Mr. Johnson has erred greatly in his aforesaid estimate of suspended matter that will be re-
4012 moved by the proposed ½ inch screens from the sewage of the Passaic Valley District.

Q. Taking into full consideration the entire testimony you have heard given by the witnesses produced by the defendants at Newark, New Jersey, together with your own personal observations, experience and research, and the recorded experiences and experimental investigations of recognized scientific authorities on sewage and sewage disposal, what in your opinion will be the condition of the sewage effluent proposed to be discharged by the Passaic Valley Sewerage Commission near Robbins Reef Light, and in your opinion will it or will it not create a nuisance?

Mr. Riker: Same objection as to the last question.
The Commissioner: Same as before.

A. In my opinion the sewage effluent will have an offensive odor in warm weather; it will then be in a septic condition creating an odor nuisance. It will also be strongly turbid.

Mr. O'Sullivan: He is your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. In the testimony which you have given what effluent have you assumed as the basis of your testimony?

A. An effluent coming from the proposed sedimentation tanks of the Passaic Valley Sewerage District, these tanks being located on the shore of Newark Bay in the southern part of the present City of Newark.

Q. You say the proposed work? Do you know what is actually proposed by the Passaic Valley Sewerage Commissioners?

A. I have seen plans that were prepared by the engineers of the Passaic Valley Sewerage Commission, and I believe that those plans represent the intentions of the Passaic Valley Sewerage Commission.

Q. Why do you believe that? On what do you found your belief?

A. My belief is founded on the title of the plans.

Q. When were they made, do you know?

A. I do not know definitely. The dates are, I believe, inscribed on those plans.

4013 Q. Can you say whether——

A. (Interposing.) I saw the plans in 1912 or 1911.

Q. Well, what was the date; when were they made, do you know?

A. I do not remember the dates written on these different plans.

Q. Were they within 5 years of the present time?

A. Yes, sir.

Q. You are sure of that?

A. Yes, sir. They were made subsequent to the date of the publication of the report of the Passaic Valley Sewerage Commission in 1908.

Q. How long subsequent?

A. I cannot tell that definitely from memory. The titles of the plans and maps will indicate that.

Q. Will those plans, as you say, you understand that they were proposed by the Passaic Valley Sewerage Commissioners, produce an effluent, the result of which will be as guaranteed in Complainants' Exhibit No. 135 when discharged into New York Bay?

A. I do not think they will; I do not think that the effluent will comply with the conditions there set forth.

Q. Well, do I understand you then, that you do not believe that the Passaic Valley Sewerage Commissioners propose to produce such an effluent that will result as stated in this stipulation entered into by them and the State of New Jersey with the Government of the United States of America?

A. No, I do not wish to state that the Passaic Valley Sewerage Commission has any intention of avoiding the stipulations, but I refer to the plans of that commission as I have seen them of recent date.

Q. But Mr. Kuichling, you said that the proposed works would result in a nuisance in New York Harbor. Now, if the effluent that is intended by the stipulation is the effluent that is proposed by the Commissioners, in your opinion will it or will it not be necessary to introduce other works into the disposal plant?

A. It will be necessary to introduce other methods of operation and possibly additional works.

Q. Why do you say then—do you mean to say then that

4014 the commissioners do not intend in producing the effluent which they have stipulated to produce, to introduce whatever works and processes are necessary?

A. No, sir, I do not say that. I merely say that in these stipulations certain structures are prescribed. I infer from the language of the stipulations that it was the belief at that time that these structures of the dimensions described would comply with the results called for. It is my opinion that they will not comply.

Q. And do you not also infer from the language of the stipulation that if these things that are specified do not produce the results that the commissioners will introduce others?

A. I see no evidence as yet that has been offered anywhere that

the Passaic Valley Sewerage Commission intends to provide additional plant or methods of operation.

Q. That is hardly an answer to my question, Mr. Kuichling I ask you now to look at the stipulation itself at the beginning of the second paragraph, and see whether you do not find indications that if the belief in the efficiency of the specified plant is mistaken, that the commissioners proposed to introduce other processes or works which will result in the effluent producing results as guaranteed in the stipulation?

A. I read in the second article of the stipulation that the results shall be secured either through compliance with the requirements of the immediately preceding paragraphs or through requisite, lawful additional arrangements. Now, there is an alternative. It is either one of two things.

Q. I ask you whether you do not get from the stipulation itself a sufficient intimation and assurance that if the specified plant and works and processes will not produce the effluent, that there will be others introduced which will produce the effluent?

A. I do not see it from the language there, because an alternative is proposed. It is either the prescribed plant or through requisite, lawful additional arrangements. Now, I may be, perhaps, a little doubtful about the meaning of this language. To me it is ambiguous. It presents an alternative, the choice between two things.

4015 Q. You think the commissioners have the choice of doing one or the other?

A. Yes.

Q. And do you think, then, they have any choice about producing an effluent under this stipulation in accordance with the terms of the stipulation?

A. Well, if they comply with the requirements, the physical requirements, set forth, I do not see that the character of the effluent has much to do with the case.

Q. You do not see that they have guaranteed—you do not understand from this, then, that they have guaranteed results in New York Bay from the effluent, is that what you mean?

A. Yes, because they have the choice of two things. They can either comply with these prescriptions, set forth, or they can put in additional things. It leaves it perfectly optional.

Mr. Riker: I do not think I want to ask you any more questions, Mr. Kuichling. I think that will do for you.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Kuichling, have you seen the detailed plans of the Passaic Valley Sewerage Commissioners prepared by Edlow Harrison and William G. Taylor, for December 1910, undertaking to comply with these stipulations, so far as producing an effluent that will give the results guaranteed?

A. I have seen a large number of such plans.

Q. Of the dates that I have stated?

A. Of the dates stated by you.

Q. Will the plans that you have seen for the sewage disposal system to be installed on Newark Meadows yield the effluent that is stipulated for or whose results are guaranteed in Complainants' Exhibit No. 135?

Mr. Riker: This question is objected to, because this witness has said that he does not understand that any such thing was guaranteed in the stipulation.

The Commissioner: Note the objection of Counsel for the Defendants.

The Witness: They will not.

Mr. O'Sullivan: That is all.

Adjourned to Tuesday morning, June 3rd, 1913 at 10:30 A. M.

4016 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, June 3rd, 1913—10.30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the people of the State of New York, Complainants.

Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

FREDERICK W. SCHWARTZ, a witness for the Complainants, called in rebuttal, being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Doctor?
A. Frederick W. Schwartz.
Q. Where do you reside?
A. Albany, New York.
Q. What is your profession?
A. Doctor in chemistry, Rensselaer Polytechnic Institute.
Q. Where did you pursue your technical studies, Doctor?
A. I received the degree of Bachelor of Science, from the Rensselaer Polytechnic Institute, and the degree of Doctor of Philosophy from the Columbia University, New York City.

4017 Q. Did you go out somewhat recently on New York Bay with Professors Phelps, and Mason for the purpose of taking samples of the Bay water and subjecting the same to analyses for dissolved oxygen?

A. I did.

Q. Upon what dates did you go?

A. April 21st, 22, 23, 24, 25, and 26th, 1913.

Q. What portions of these days did this work occupy?

A. It occupied from 9 o'clock in the morning until about 4 o'clock in the afternoon.

Q. At what points were the samples taken, and also the depths at which they were taken?

A. The samples were taken about half a mile northeast of Robbins Reef, and in mid-channel of the Kill Van Kull, opposite Sailors Snug Harbor, and the depths were 5 feet, 10 feet, and 20 feet below the surface.

Q. When were these samples that were taken as you have described subjected to analyses for dissolved oxygen?

A. The samples were analyzed upon the launch immediately after being taken; that is, after the samples was taken the analysis was started immediately, and the boat headed for the other sampling station, the time of analysis being about 30 minutes; that is the time necessary for the boat to make one trip between the two sampling stations.

Q. How many samples in all were taken during the days that you have stated?

Mr. Riker: I object to this testimony on the ground that it is not rebuttal, not directed to anything in the testimony of the defense. The testimony of the defense did not deal in any respect with the analyses of Harbor waters.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: This line of inquiry is pressed by Complainants' Counsel for the reason that certain statements were made by George A. Johnson an expert called by the defendants,
4018 relative to the sewage to be discharged at the outfall at Robbins Reef, and as to the Condition of the waters going through the Kill van Kull, and this testimony will be connected later in direct refutation of the statements made by Mr. Johnson.

The Witness (answering): 224 samples.

Q. Will you describe the method used in making the analyses or the oxygen determinations that you have testified to?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

The Witness (answering): The method used was the Levy Method, the original Levy Method, which consists of a standard pipette having stop-cocks at each end, one end being a funnel top. The sample of water having been put into the pipette, the stop-cocks are closed. 2 cubic centimeters of sodium hydroxide are added in the funnel. The lower stop-cock is opened and the

upper stop-cock cautiously opened until the re-agent enters the pipette. After the re-agent has entered the pipette, both stop-cocks are closed, the funnel is thoroughly rinsed in distilled water, then 3 cubic centimeters of ferro sulphate solution are added to the funnel, and the stop-cocks are opened again for the other re-agent. Then after the re-agent has entered, both stop-cocks are closed, and the pipette is shaken. This produces ferrous hydroxide, which in the alkaline solution is oxidized by the oxygen of the water if it be present, to ferric hydroxide. After a lapse of 10 minutes or more, 2 cubic mentimeters of concentrated sulphuric acid are added to the funnel, the upper stop-cock only is opened, and the strong acid allowed to run into the solution. This makes the solution acid, dissolves the hydroxides of iron and makes the solution clear. It is then run into a flask or casserole and titrated with standard potassium permanganate solution. After this has been done, a blank is run using the same quantity of water, but changing the order of the addition of the chemicals. In this case the acid is added
4019 first, then the sodium hydroxide and then the ferrous sulphate solution. The titration is made as before with standard potassium permanganate. From the amounts of potassium permanganate used for the sample and for this blank we deduct from the blank the amount used by the sample and substract for the volume of the re-agents added, multiplied by the volume in cubic centimeters of oxygen of the permanganate, and calculate the results to cubic centimeters of oxygen per litre.

Q. Have you fully described the method known as the original Levy Method, now, Doctor Schwartz?

A. This is the original Levy Method

Q. Is it a recognized method of analysis for oxygen determinations?

A. It is.

Q. Why did you choose that particular method?

A. It is the method used by the Metropolitan Sewerage Commission of New York City.

Q. What other observations were made at the time of taking these samples?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. A record of the temperature of the water and of the condition of the tide was also made and recorded.

Q. Did you keep full notes of what samples were taken, the time of day at which they were taken, and the analytical results secured?

A. I did.

Q. Have you got your laboratory note books with you?

A. Yes, sir.

Q. Will you give me the number of samples that was taken at the two different points that you have stated that you took samples from on each of these days in April?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. On April 21 at Robbins Reef there were 13 samples taken, at Kill van Kull, there were 7 samples taken. On April 22nd at Robbins Reef there were 19 samples taken, and at Kill van Kull 20 samples. On April 23rd, there were 24 samples taken, and at the Kill van Kull 20 samples. On April 24th, at Robbins Reef, 20 samples, and Kill van Kull 16 samples. On April 25th, at Robbins Reef 28 samples, and at Kill van Kull 24 samples. On April 26th, at Robbins Reef, 18 samples, and 15 samples at the Kill van Kull.

4020

Q. Have you made an average of your detailed results showing the amounts of dissolved oxygen present in the water at the two sampling stations, and if so, will you state what they were, Doctor?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. In cubic centimeters of oxygen per liter.

	Robbins Reef.			Kill van Kull.		
Average of	Ebb.	Flood.	Average.	Ebb.	Flood.	Average.
5' samples	5.97	6.29	6.08	6.05	6.25	6.12
10' "	5.90	5.98	5.96	5.94	6.00	5.96
20' "	6.01	5.73	5.87	6.02	6.23	6.09

Q. Doctor Schwartz, did you secure other samples of water for other purposes, and if so state for what purposes, and to whom you delivered them?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I took samples of water for the Bacteriological examination and those were taken for four days, three of those days the samples were delivered to Professor Phelps, the fourth day they were delivered to Mr. Bonney.

Q. In what shape or condition were they when you delivered them; how did you prepare them for delivery?

A. The bottles were sterilized; when I received them the samples were placed in the bottles. The bottles were placed in a copper box which had a bottom or container for ice. This whole box was then placed in a fibre case, and it was in that form the samples were delivered.

Q. By whom?

A. I delivered them in that condition to Professor Phelps on the three days, and on the fourth day to Mr. Bonney.

4021

Mr. O'Sullivan: He is your witness.

Mr. Riker: No questions.

ALSON BONNEY, a witness in behalf of the Complainants, called in rebuttal, being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your name, Mr. Bonney?
A. Alson Bonney.
Q. Are you connected with any laboratory in the City?
A. Yes sir.
Q. Whose laboratory?
A. Doctor North's laboratory.
Q. In April did you receive any samples of water for bacteriological examination from anyone?
A. I did.
Q. From whom?
A. On three days from Professor Phelps, and on one day from Doctor Schwartz.
Q. How did you receive these samples and what condition were they in when you received them?
A. The samples were received in 2 ounce bottles, and the bottle were in an ice pack.
Q. What did you do on receiving the package with the bottles as you have described?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any testimony offered by the defence.

The Commissioner: Note the objection of counsel for the defendants.

A. These were immediately taken to Doctor North's laboratory.
Q. Describe what you did now, Mr. Bonney, with them?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. The samples were now analyzed for B. coli and bacteria contained according to the method set forth by the standard method of the American Public Health Association.
Q. Will you describe in detail how you made these determinations, Mr. Bonney?

4022 Mr. Riker: Same objection.
The Commissioner: Note the objection.

Mr. O'Sullivan: Describe what you did, how you did it. Give whatever specific tests you applied in making your bacteria examinations.

The Witness: In analysing for the bacteria contents we used 2 Petrie dishes, one for 37 degrees temperature, and one for 20 degree temperature. In both these plats were placed 1 Cc. of water, and to this was added agar agar media. These plates were then placed in an incubator at the prescribed temperature, and allowed to stand for the required number of days for the B. coli determination we used 10 bile tubes to each sample. Into these tubes were inoculated

1 cc. of water, and these tubes allowed to stand in the incubator at the proper temperature for the number of days.

Q. After starting the operations that you have just described, who completed those?

A. Doctor North observed and recorded the results of the analyses.

Mr. O'Sullivan: He is your witness.

Cross-examination by Mr. Riker:

Q. Do you know where the samples came from?

A. Yes, the samples came from the Harbor of New York City.

Q. How do you know?

A. Why, I was on the boat when the last set of samples were taken, and Professor Phelps told me the other sets were taken from there.

Q. Your belief rests then, in part upon Professor Phelps' word to you?

A. On the first three days, yes sir.

Q. Well, don't you think that is a basis for stating that you know where this came from.

A. On the last day I know where they came from.

Q. As to the other days, do you know?

A. Only what Professor Phelps told me.

Mr. Riker: That is all Mr. Bonney.

4023 CHARLES E. NORTH, a witness in behalf of the Complainants, called in rebuttal being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Doctor?

A. Charles E. North.

Q. And what is your profession?

A. Consulting sanitarian.

Q. Where did you pursue your technical studies, Doctor; state what degrees you took?

A. I got the degree of A. B. at Wesleyan University, Middletown, Connecticut, specializing in chemistry and biology; M. D. at Columbia University, New York.

Q. Have you specialized in your profession now?

A. Yes, sir.

Q. What specialty?

A. Consulting sanitary work connected with, particularly, water supplies and milk supplies.

Q. Did you hear the last witness, Mr. Bonney, testify?

A. Yes sir, I did.

Q. Is he connected with your laboratories?

A. He is one of the assistants in my laboratories.

Q. Did you hear him describe what he did with certain samples which he received from Professor Phelps?

A. Yes sir, I did.

Q. And certain samples which he testified he received from Doctor Schwartz?

A. Yes sir.

Q. What did you do in connection with those samples?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any testimony offered on behalf of the defence.

The Commissioner: Note the objection of Counsel for the defendants.

A. I instructed Mr. Bonney how to analyze these samples, how to start the analysis and then I personally inspected all of the samples which he had placed under cultivation, and at the end of the required period of time I noted the results and recorded the same, and sent a report to Professor Phelps.

Q. What special tests did you apply in your bacteriological determinations, Doctor North?

4024 Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I used the tests prescribed by the standard methods for the bacteriological analysis of water, and of sewage by the American Public Health Association. These tests are three in character, the first relating to the number of bacteria present by the plate method at 2 degrees of temperature, namely, the blood heat of 37 degrees centigrade and the room temperature of 20 degrees centigrade; and the second test which has as its object the determination of the relative number of acid-forming organisms and other species of bacteria by the use of Lactose litmus ager plates. The third test is called the fermentation test for B. coli by the use of lactose bile. This has as its object the determination of the number of B. coli present in one c. c. or fractions thereof.

Q. What was the result of your bacteriological analyses of the samples of water?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I have tabulated the results in the form of a report showing the number of samples taken and the number of bacteria present in each sample by the plate method, and also the number of acid-forming organisms if the lactose litmus agar, and the number of fermentation tubes in which gas was formed. These all appear in detail on this report.

4025 *"Results of Bacteriological Examination of Samples of Water Taken from New York Harbor on Dates Given Below.*

Date.	Lab. No.	Description.	Bact. per c. c., 24 hrs., 37°.	Lact. Lit. agar, 24 hrs., 37°.		Bact. p'r c. c., 48 hrs., 20°.	Fermentation tubes, 1 c. c. ea.	
				Red.	Others.		Pos.	Neg.
4/22.	7091.	Mkd. No. 2	90	15	75	600	10	0
	7092.	" " 4	140	20	30	640	10	0
	7093.	" " 9	450	90	300	3,200	1	9
	7094.	" " 15	160	40	30	400	10	0
	7095.	" " 20	1,200	100	600	1,600	10	0
	7096.	" " 25	280	50	30	320	10	0
4/23.	7114.	" " 30	800	40	480	3,200	10	0
	7115.	" " 35	400	20	560	800	10	0
	7116.	" " 41	640	140	560	3,600	10	0
	7117.	" " 45	640	5	1,120	3,200	10	0
	7118.	" " 50	2,000	400	800	8,000	10	0
	7119.	" " 55	800	45	400	800	10	0
	7120.	" " 60	2,400	400	1,200	1,200	10	0
	7121.	" " 65	1,600	0	1,000	1,280	10	0
	7122.	" " 70	1,240	0	240	3,600	8	2
	7123.	" " 75	640	20	560	1,280	10	0
							1/10 c. c.	
4/24.	7132.	" " 80	80	30	60	300	10	0
	7133.	" " 85	50	0	20	100	2	8
	7134.	" " 90	50	30	40	300	6	4
	7135.	" " 95	200	0	100	500	10	0
	7136.	" " 100	80	60	40	500	6	4
	7137.	" " 105	750	170	200	2,400	10	0
	7138.	" " 110	300	40	60	800	4	6
	7139.	" " 115	600	120	200	3,200	10	0
	7140.	" " 120	300	20	40	500	10	0

4026

Date.	Lab. No.	Description.	Bact. per c. c., 24 hrs., 37°.	Lact. Lit. agar, 24 hrs., 37°.		Bact. p'r c. c., 48 hrs., 20°.	Fermentation tubes, 1 c. c. ea.	
				Red.	Others.		Pos.	Neg.
4/24.	7141.	Mkd. No. 125	2,000	400	400	5,000	8	2
	7142.	" " 130	400	130	250	1,600	8	2
4/25.	7150.	" " 135	150	50	50	500	8	2
	7151.	" " 140	100	50	70	600	8	2
	7152.	" " 145	100	50	50	1,100	4	6
	7153.	" " 150	300	40	200	2,500	6	4
	7154.	" " 155	400	50	100	950	6	4
	7155.	" " 160	1,600	40	80	4,000	6	4
	7156.	" " 165	250	150	100	1,200	8	2
	7157.	" " 170	4,006	800	600	3,000	8	2
	7158.	" " 175	150	0	50	670	4	6

Mr. O'Sullivan: He is your witness, Mr. Riker.
Mr. Riker: No questions.

EARLE B. PHELPS, a witness in behalf of the Complainants, recalled in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. You have testified previously in this suit, Professor Phelps, have you not?

A. Yes sir.

4027 Q. Now, has your attention been directed to the testimony of Mr. George A. Johnson at pages 3960 and 3962 relating to the collection and examination of specimens of sewage from the outlets of thirteen sewers discharging into the Passaic River at various specified points between Paterson and Newark?

A. Yes sir, it has.

Q. Does the mode of collecting and the deductions made by Mr. George A. Johnson conform with your experience under like conditions, and if not, state fully why not?

A. They do not. In his description of the method of collecting the samples as found on page 4060 of the typewritten record Mr. Johnson states "In some cases it was not feasible to enter the sewer and in those cases a large bucket of the sewage was drawn up from the sewer and the sample bottle filled from it as above described." In the course of an investigation of the sewage of the City of Boston, which extended over about eight years, I had occasion to make a careful study of the best method of collecting samples of sewage for the dissolved oxygen test. Water in its pure state or mixed with other ingredients such as we find in sewage has a great tendency to dissolve oxygen from the atmosphere. Under any given state of conditions there is a maximum amount of oxygen which can be thus dissolved and water which holds that amount in solution is said to be saturated. A saturated water, therefore, can dissolve no more oxygen. Normal or unpolluted waters which are unpolluted naturally contain a full quota of oxygen or practically so. It has been found necessary in collecting samples for analysis to absolutely preclude any contact of the water to be examined with the air. As the percentage of saturation is diminished by contained impurities, the water seizes oxygen from the air with greater and greater rapidity. In the case of sewage where the oxygen content is always low and is sometimes actually zero, the rapidity with which oxygen is dissolved by the water upon exposure to the air is very great and the precautions necessary to prevent such solution must be extremely

4028 rigid. The method of collecting a bucket of sewage from the sewer and later taking this off into bottles is faulty in the extreme and results obtained by any such method will necessarily be unreliable. Moreover, they will always be higher than the true value.

Q. Higher in what?

A. In dissolved oxygen.

Q. What does the presence or the absence of dissolved oxygen in sewage depend upon?

Mr. Riker: I object to that as not rebuttal of any testimony offered on behalf of the defence.

The Commissioner: Note the objection of Counsel for the defendants.

A. The presence or absence of dissolved oxygen in sewage depends entirely upon the condition of the sewage as regards its age and its temperature. All sewages, if examined at a sufficiently early stage, show the normal dissolved oxygen of the water supply which makes up their principal volume. The mere presence of dissolved oxygen in sewage is in no sense a measure of the character of that sewage, nor can one determine by such analytical data the effect of the discharge of such a sewage into a stream. The statement that the discharge of sewage containing from 50 to 75 per cent of saturation of oxygen into a river which may contain less dissolved oxygen at that time exerts a refreshing action upon the river is misleading. Consideration of the dissolved oxygen in sewage is strictly equivalent to the consideration of the assets in a bank statement. A complete interpretation of conditions requires also a consideration of the liability side of the balance sheet. The opposing side in the sewage analysis is the amount of oxidizable material present. A correct impression of the character of the liquid can only be obtained by a comparison of these two values, namely, the dissolved oxygen or oxygen resources on the one hand, and the oxidizable organic matter or oxygen requirements on the other. This position is obvious if we consider the comparative oxygen balance of a fresh sewage and of the New York Harbor water, assuming both to contain
4029 70 per cent of saturation of dissolved oxygen. In the case of a harbor water the oxidizing reactions that have taken place have produced a condition of essential equilibrium. A sample of this water if stored in a tightly stoppered bottle for twenty-four hours will lose little if any of its dissolved oxygen during that time; whereas a sample of the sewage containing at the start the same actual amount of dissolved oxygen, similarly stored, will lose all of that oxygen within an hour or so.

It is this balance or deficit of dissolved oxygen obtained by comparing the available oxygen with the oxygen requirements of the liquid that determines its actual character and its influence upon any stream into which it may be discharged. It is entirely improper to use the dissolved oxygen figure alone as a criterion or measure of condition.

When sewage is diluted in a large volume of water containing a reserve of dissolved oxygen, bio-chemical reactions are set up which result in the withdrawal of oxygen from the water and equivalent oxidation of the organic matter in the sewage. This process continues until it comes into virtual equilibrium, at which point the stream is able to obtain by reaeration from the atmosphere as much oxygen as is required for the continuance of the oxidizing reaction. Complete equilibrium is only obtained when the reaction itself has

been fully carried out. Studies which I carried out some years ago on the capacity of New York Harbor to receive and digest sewage indicated that the average sewage which is now being discharged into New York Harbor requires — the summer time approximately 2,000 pounds of oxygen for each million gallons of sewage before a condition of virtual equilibrium would be reached. Converted into our ordinary analytical units this is equivalent to approximately 240 parts per million of dissolved oxygen or 2.700 per cent of saturation. This means that if — given a volume of sewage were 100 per cent saturated with oxygen it would still show
4030 a- oxygen deficit equivalent to twenty-six times its total available oxygen. Expressed in another way, such a sewage if diluted in twenty-six equivalent volumes of pure water also saturated with oxygen would entirely exhaust not only its own oxygen supply but the entire supply of these additional twenty-six volumes of water. The implication, therefore, conveyed in the statement made by Mr. Johnson that sewage because it had 50 or 75 per cent of dissolved oxygen would exert a refreshing reaction upon a stream containing a less per cent of dissolved oxygen is erroneous and misleading. Fifty per cent of dissolved oxygen in an average city sewage represents approximately a 54th part of the amount of dissolved oxygen required by such a sewage before it would reach equilibrium, so that this 50 per cent of saturation, instead of representing an asset, represents a very seirous deficit. It is quite immaterial from the point of view of river pollution how much oxygen the sewage may happen to contain at the time of examination. As I have previously stated if it could be examined at a sufficiently early stage, sewage would contain nearly 100 per cent of saturation. This is because of the fact that the sewage as it enters the sewer is made up in the greater part of its bulk by fresh water from the city mains, which is normally saturated with dissolved oxygen. If the sample be examined before the biological reactions, which begin at once, have progressed materially, one can obtain nearly 100 per cent of saturation in any city sewage. All sewages are similar in this respect and they are similar in the further respect that within a comparatively few hours, the time depending upon the temperature and rapidity of the biological reactions taking place this dissolved oxygen will have become exhausted and there will still be an oxygen requirement left in the sewage, which is so much greater than the amount of oxygen originall- present that that latter amount becomes a non-essential detail.

Q. Have you recently made an investigation of the actual present condition of the waters near Robbins Reef Light and the Kill van Kull?

A. I have.

4031 Q. Were you present when Doctor Schwartz testified just now?

A. I was.

Q. Were you present when Mr. Bonnev testified?

A. I was.

Q. Did you hear both witness-' testimcny?

A. I did.

Q. Where did you receive the samples of water that you gave to Mr. Bonney?

A. Those samples that have been testified about were collected by Doctor Schwartz in my presence, and under my oversight and under Professor Mason's oversight, who was present also, on board the launch upon which we made the trips down the Harbor on the days mentioned, April 21, 22 and 23. Two sampling stations were established on those days: One at a point one-half mile northeast of Robbins Reef light, on the edge of the channel, the other in mid-channel in the Kill van Kull, at a point directly opposite the Sailors Snug Harbor. At each of those stations, samples for the determination of the dissolved oxygen were taken, and also samples for bacteriological examinations. The latter samples were all taken at a depth of 10 feet below the surface.

Q. Were you present, and did you hear the testimony given by Doctor North as to the results of his bacterial investigations on these samples?

A. I did.

Q. Now, in what did your investigations consist, Professor Phelps?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. My investigations consisted more particularly in the chemical work to which I have referred. In conjunction with Professor Mason I laid out a program for that work and also in conjunction with him and with Doctor Schwartz started that work off, and for three days was with the boat seeing all the operations, and assisting in some of them. My further investigations included a compilation of the results and the detailed study of them in their interpretation. The work was undertaken for the purpose, among other things, of determining the oxygen balance of the waters in the neighborhood of Robbins Reef Light House, and near the point of discharge of the Passaic Valley sewer, for the purpose of comparison with similar waters from the Kill van Kull. Any part
4032 of the sewage from the territory to be served by the proposed Passaic Valley sewer which now enters New York Harbor does so through Kill van Kull. This amount of polluting material has before reaching the waters of New York Harbor been subjected to certain processes of natural purification in the Passaic River and in Newark Bay and it was thought desirable to determine the condition of the oxygen balance as this polluting material reached New York Harbor through Kill van Kull.

For this purpose, in addition to the regular determinations of the dissolved oxygen in the water at various stages of the time, samples were taken simultaneously for storage in tightly sealed bottles. At the expiration of twenty four hours, the samples having been maintained in the meantime at a temperature of approximately 20 degrees centigrade, a second determination of dissolved oxygen was made upon these stored samples. Actual agreement between the first and second values thus obtained would indicate a condition

of complete equilibrium and would show that the polluting material reaching New York Harbor through the Kill van Kull had been so completely oxidized that it would throw no additional burden upon the waters of New York Harbor. Any loss of dissolved oxygen in the process of storing would indicate a departure from this ideal condition and would show the magnitude of the load, placed, upon the waters of New York Harbor by the polluting material reaching it in this way. The results actually show a condition of virtual equilibrium, that is to say, there is a slight loss in dissolved oxygen observed during the period of storage but the actual amount of this loss is insignificant and it can be safely asserted that no serious additional burden is being placed upon the purifying capacity of New York Harbor waters by the pollution which reaches the Harbor through the Kill Van Kull.

Comparison of these results also with similar results from the vicinity of Robbins Reef shows that the waters reaching the Harbor from the Kill Van Kull are slightly superior in character to the waters of New York Harbor, and that, therefore, under pres-
4033 ent conditions, the pollution from the region of the Passaic Valley that now reaches New York Harbor is relatively equal to, and certainly is no greater than, the pollution of New York Harbor from other sources, when these two separate sources of pollution are considered with reference to their respective dilutions and the volumes of oxygen bearing water with which they are respectively mixed. Expressed in another way, the oxygen balance relation between the present New Jersey pollution and the total tidal waters of Newark Bay and other waters by which that pollution is diluted is not dissimilar to the corresponding oxygen balance between the pollution from all other sources, and the diluting tidal waters with which the latter are mixed. It is this oxygen balance relation which must be kept in mind as the proper basis for comparing various classes of polluted water. The sewage of the Passaic Valley district is now by natural means brought into a state of virtual equilibrium before it reaches New York Harbor. This equilibrium is approximately of the same degree of completeness as exists in the remaining waters of New York Harbor and whatever may be said on the side of the necessity for further improvements of conditions in New York Harbor it can at least be said that the present distribution of the oxygen reserve of all the Harbor and tributary waters taken together among the various communities polluting these waters is at least an equitable one.

The proposed discharge of a large volume of sewage at the Robbins Reef outlet would alter seriously the present conditions. There would first of all, be a slightly beneficial effect upon the waters of Newark Bay and the Kill Van Kull, and there would next be a distinctly detrimental effect upon the waters of upper Harbor. It will be necessary for me to consider these two resulting effects in order to determine whether the benefit on the one side is sufficient to balance the detriment on the other. I have stated that the gradual is at a maximum. Under this condition *on* the body of water in which it is diluted, reducing thereby the dissolved oxygen of that

water. The greater such reduction the more rapid the
4034 absorption of additional oxygen from the atmosphere until a condition of equilibrium is reached at which the absorption is at a maximum. Under this condition *on* the body of water in question may be said to be doing its maximum purifying work. Newark Bay is in such a condition of equilibrium, and the result of the examinations which we have made shows that the aeration and other factors in the Bay have brought about practically complete equilibrium, the complete oxidation of the polluting matter. Moreover, Newark Bay has not suffered seriously, but has been able to maintain its own condition by re-absorption of oxygen from the atmosphere. By removing pollution from Newark Bay these waters will have less work to do, will absorb less oxygen from the atmosphere and will reach New York Bay in so far as they travel in that direction in a condition somewhat better than their present condition. This slight improvement, however, will add little or nothing to the purifying capacity of New York Harbor itself. The ebb waters through the Kill Van Kull flow to a rather large extent directly out through the Narrows, so that they exert a minor influence upon the character of the New York Harbor waters. In the second place, the total volumes that are affected by the flow through the Kill Van Kull are small compared with the total volume of New York Harbor. The net effect, therefore, of removing all sewage pollution from Newark Bay would in consideration of all these various factors be extremely small. The Passaic Valley district is not to-day an important factor in the pollution of New York Harbor waters. On the other hand, the additional of a large volume of sewage to the upper New York Bay would throw a heavy burden upon the purifying power of those waters. All the oxidizing work which Newark Bay is now doing will have to be done in New York Bay. The discharge of 350 millions gallons of sewage at Robbins Reef would throw such a burden upon the waters of New York Bay that the dissolved oxygen would be lowered to at least 40 per cent of saturation by the most conservative calculation. This calculation is based upon the average oxygen requirement of city sewage
4035 and upon the power of reaeration existing in New York Harbor determined by methods that are all in evidence in my direct examination. The continued discharge of this volume of sewage under all tidal conditions would result in carrying pol-ution to the uppermost limits of New York City and computations of the effect of such discharge upon the waters of the Hudson River at Spuyten Duyvil show that during the summer season the dissolved oxygen at that point would be reduced on the average of 25 per cent of saturation. For comparison of this figure, I wish to state also that some determinations of the dissolved oxygen of the Passaic River at Newark, made in January, 1911, by me, showed that the waters of the Passaic River at Newark contained at that time 38 per cent of saturation of dissolved oxygen. This figure is in evidence in Complainant's exhibit No. 136, page 17. The deep waters of New York Upper Bay and the Hudson provides a great dilution factor but are less efficient in aeration than the waters of Newark Bay.

Therefore, work which Newark Bay with its broad shallow reaches would be relieved by this change without any material advantage to that Bay would be placed directly upon the New York Bay waters which are much less favorably situated for purification work.

Q. Professor Phelps was your attention particularly directed to the testimony of Mr. George A. Johnson at pages 4121 and 4122 relating to the larger suspended particles, and as to their being according to Mr. Johnson's testimony more putrescible than the smaller suspended particles?

A. Yes sir. I have read that testimony carefully.

Q. Will you state what is the relative stability of large and small particles of colloidal and dissolved material in suspension?

A. In any discussion of sewage purification methods the use of such a term as "percent of removal of suspended solids" is apt to be misleading unless one has in mind very clearly the purposes for which that sewage purification is undertaken. If the object of the purification is to remove suspended material because such material might otherwise deposit upon the banks and bed of a slow moving stream and thereby give rise to a nuisance or obstruction due
4036 directly to the fact that material was deposited, then the amount of material removed is a direct measure of the efficiency of the process.

If, on the other hand, the nuisance to be abated is of a bichemical sort and is manifested by a loss of dissolved oxygen in the stream due to the putrefaction of organic matter, then the expression quoted "percent removal of suspended matter" is no true index of the efficiency of the process and must be carefully interpreted in the light of other knowledge before it become useful information.

In the particular case at hand, we are not concerned primarily with a possible deposit of material for it can be shown that this can never be so serious as to interfere with navigation; but we are concerned with the capacity of New York Harbor to receive and assimilate pollution without suffering an undue loss of dissolved oxygen. Therefore, any statement of the removal of suspended solids may be misleading with the further statement of the effect of such removal upon the actual putrescibility or oxygen requirements of the sewage.

To understand this matter properly one must first consider the time factor in its relation to the oxidation of organic matter. We may for purposes of illustration imagine two samples of polluted water each having the same total oxygen requirement, so that each would ultimately exert the same effect upon the body of diluting water into which they might be discharged; but owing to the varying physical conditions of the organic matter in these two samples, it is quite possible and is frequently observed that in a given period of time, say six hours, the oxidizing reaction might proceed to 50 per cent of completion in the one case and to only 25 per cent of completion in the other. If during that six hours a further dilution occurs or if the water be exposed in comparatively shallow depths, or agitated so that considerable reaeration is possible, then it is obvious that the material which is oxidized slowly would produce a much

less serious result in the stream than the material which is
4037 oxidized rapidly even though the total amount of oxygen requirement in the two cases be the same.

We have observed in the case of sewage now entering New York Harbor that the mere difference between summer and winter conditions in the sewer itself result in a ten fold increase in the rapidity of oxidation of the organic matter, even though the total oxygen requirements of the sewage are not materially altered. One of the principal reasons for this variability has been found to be the physical condition of the organic matter. This point has been investigated in much greater detail by Doctor Lederer of the Engineering Staff of the Chicago Sanitary District at the Experiment Station at Chicago. In a paper presented before the American Public Health Association Lederer showed as the results of his investigations that the rate of oxidation of suspended matter increases with increased fineness of material and that the same rule holds also with the still finer particles which may be termed colloidal material and material in true solution. He showed by conclusive experiments that a removal of 60 per cent of a suspended matter resulted in a removal of only 30 per cent of the putrescibility due to suspended matter. This variation is doubtless emphasized also by the fact that the grosser suspended material is composed in large measure of organic material which is actually less putrescible, such as street washings, paper, etc.

Our investigations made upon the Boston sewage enabled us to extend this principle in both directions. I have already shown that the greater percentage of soluble material, which results from the putrefaction within the sewer in warm weather brings about a very great rise in the rate of oxidation so that in summer the total effect is at times increased ten fold over winter conditions. At the other extreme the principal has been illustrated by studies of the relative stability of material removed by fine screening, such screening material being composed largely of paper, rags, matches, cork and
4038 other coarse matter was shown to have such a low rate of oxidizability that it was practically negligible. Although the removal of suspended organic matter by fine screening amounts to a relative high percentage of the total organic matter present and although fine screening is exceedingly desirable for other reasons, it can — be stated that such screening does not materially improve the character of the sewage as regards its rate of oxidation, and the resulting effect upon the stream into which it is discharged. The operation of screening and sedimentation applied to a sewage having the average age which the sewage of the proposed Passaic sewer will have upon reaching the purification works will in my opinion bring about two changes in the character of the sewage, these changes being of an opposite nature. There will be in the first place a removal of the gross material by screening and of a definite proportion of the heavier suspended solids by sedimentation. This will tend to reduce the total oxidizability of the sewage in question to an extent which will be much less than that indicated by the relative removal of organic impurities. The time required for the sedimentation will

also provide for further decomposition in the sewage which will have the same effect in aging the sewage as would be had by increasing the temperature. That is, this additional storage will make the sewage more readily oxidizable and this increase in the rate of oxidation will in my opinion more than offset any advantage obtained by the removal of suspended matter. In addition to the general observations which I have made upon various sewages along this line, the view I have expressed here has been directly confirmed by experiments made by me at Providence during the year 1911. In that case the rate of oxidation of the sewage was found in the summer time to be increased as much as 50 per cent by storage in sedimentation tanks for a period of three hours. This net increase took place despite the fact that a considerable sedimentation was occurring simultaneously. From the point of view, therefore, of net oxygen requirements of the sewage as it is discharged at Robbins
4039 Reef within a period of six or twelve hours after discharge, it is my opinion that the proposed treatment will be of no benefit whatever and will be very likely a distinct disadvantage.

Q. Professor Phelps, will septic sewage or fresh sewage consume oxygen in larger or smaller amounts or with greater rapidity?

A. Septic will consume oxygen with much greater rapidity than fresh sewage.

Q. Sewage highly comminuted, macerated, travelling a long distance, and discharging in a septic condition—do you know of any conditions under which that could possibly benefit the body of diluent water in to which it will be discharged?

A. I do not, no sir.

Q. What gases are evolved from septic sewage.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The most conspicuous gas is hydrogen sulphide, which is an exceedingly offensive compound. It is the compound which characterizes a spoiled egg. Among others there are some organic sulphur compounds which are even more offensive than hydrogen sulphide—the so-called mercaptan. There are also amines, Compounds which characterize decomposing fish, nitrogenous matters, which are very offensive in their odor. There are phenol, indol and skator—all characteristic of decomposing fecal matter, and others that are less offensive, such as carbon dioxide, and methane, gases of that character.

Q. Is there any relation between the volume of these gases evolved, and the degree of septicity in the sewage?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The total amount of gas evolved depends upon the degree of the septicity of the sewage. The rate of evolution would depend upon the temperature.

Q. Would you expect considerable malodorous conditions
4040 evolved from the septic sewage discharged in warm weather at a point such as Robbins Reef Light, and expect those malodorous conditions to reach Manhattan Island?

A. Judging by all previous experience, I certainly would.

Mr. O'Sullivan: He is your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. What part did you have in the preparation of the stipulation between the United States and the State of New Jersey?

A. None whatever.

Q. Never submitted to you before it was executed?

A. No. I did discuss the matter with Colonel Black, the first time I ever met him.

Q. You were associated with Colonel Black in certain investigations?

A. After that, a year later.

Q. Do you recognize Colonel Black as anything of an authority in these matters?

A. I certainly do.

Q. Why do you speak of the discharge of the sewer as 350 million gallons a day?

A. Why, I think 360 millions gallons is the figure that is in evidence as the maximum amount.

Q. Why do you use the maximum?

A. In any engineering forecast of what is going to happen we look as far ahead as the works contemplate.

Q. How long ahead do you understand that is?

A. I am not certain.

Q. Don't you know?

A. If I did, I have forgotten.

Q. Don't you know it is twenty years?

A. I should not wonder.

Q. You are testifying in a suit, you understand that, do you not?

A. Yes.

Q. Which is directed at the correction of a nuisance immediately in New York Harbor, do you understand that?

A. I did not understand that we had to confine ourselves to an immediate nuisance; the sewer is to be built with a certain capacity and its capacity for discharge is 360 million gallons.

Q. And that means that it will immediately discharge 360 million gallons?

A. For all I know to the contrary it may.

Q. Do you know what the population to be served is?

A. Yes.

4041 Q. Don't you know that that population will not discharge 360 millions at the present time?

A. No.

Q. How much sewage do you estimate?

A. I know that the use of mill waste in Paterson alone amounts to 200 gallons per capita per day, and water used in washing silks, which is very foul, and make a very large item.

Q. Well, do you know how much it is estimated per capita?

A. That particular item I happen to remember about, 200 gallons per day per capita.

Q. And that happens to be the largest item there was?

A. Yes.

Q. And you are taking a maximum there to testify on, aren't you?

A. That is a possibility which may happen.

Q. Is that your method of testifying as an expert, to take the greatest possible maximum?

A. Always take the greatest possible harm that can be done by a contemplated engineering device, yes.

Q. And you are in the employ of the Metropolitan Sewerage Commissioners?

A. No.

Q. You are being paid for your testimony I suppose?

A. Yes.

Q. A regular per diem, I hope?

A. I think so.

Q. At what point is the stability which you have testified about to be reached at Kill Van Kull, at the point where you took samples, between the Oxygen and the sewage; at what point is that stability reached in the discharge of the flow of the sewage from the Passaic Valley?

A. I can only give you an opinion on that; I cannot give you any facts based on determinations.

Q. Haven't you tried to determine that?

A. No

Q. Isn't that an important factor in the matter?

A. Not at all.

Q. You do not consider it so?

A. I am only interested in the condition of the water as it reaches New York Harbor.

Q. You were interested in determining something of value for the side you are employed on?

A. Determining the facts, yes, sir.

Q. So far as they seemed to bear on the side you are employed to testify on?

A. I don't know that I have eliminated any facts that seem
4042 not to bear upon it.

Q. You were in search of facts which would tend to establish the side on which you were employed, were you not?

A. No, sir; I was in search of facts.

Q. Why didn't you attempt to discover when the point of stability is reached?

A. Because that had no possible bearing on the question.

Q. You don't think it has; that is your opinion?

A. If I had a contrary opinion, I would have sought it out.

Q. Now, you said you had an opinion on the subject; what is your opinion as to the point?

A. Of course, it is a continuous process, and no one can say it has reached a definite point, but we know the Passaic River to be in a very putrescible condition and we know the other end of the system to be in pretty fair condition, so that somewhere in the passage down Newark Bay we might assign as the point where stability is approximately reached.

Q. Somewhere in Newark Bay?

A. Yes.

Q. And that point, in your opinion, would not have been reached at the Passaic River?

A. No, certainly not.

Q. You have not investigated the oxygen contents of the river water at the mouth of the Passaic River?

A. Only in the case that I have testified to at Newark.

Q. Is that the mouth of the Passaic River?

A. No, not at the mouth at all.

Q. That is what I asked you; have you made any tests there?

A. No, I have not.

Q. Do you know what the condition of the water is from any information that has come to your ears?

A. Why, from my general information, acquaintance with such matters, I can give a pretty good guess what the condition is.

Q. Well, I asked you if you had any information as to
4043 the conditions there, not what you guessed?

A. No.

Q. What?

A. No.

Q. You can't give any information on the subject?

A. No.

Q. How do you explain the conditions, the superior conditions, of the waters of the Kill Van Kull as compared with those at Robbins Reef?

A. The proportion of pure tidal water that enters Newark Bay—the relation of the volume of that water to the volume of polluting material is greater than the similar relation in New York Harbor.

Q. Where does that pure tidal water come from?

A. It flows through the Kill Van Kull, and somewhat partly through the Arthur Kill, and the Hackensack River.

Q. Is that tidal water, the Hackensack River?

A. No.

Q. What is it?

A. Fresh water.

Q. Then it is not tidal water, from the Hackensack River?

A. No.

Q. What percentage of the tidal water comes through the Kill Van Kull?

A. Why, I cannot state in exact figures, but approximately 75 per cent, in my recollection.

Q. And that is water from where; where had it passed through; what bodies of water had it passed through?

A. Through the Narrows.

Q. What else?

A. Lower part of Upper New York Bay.

Q. Part of the New York Bay waters, was it?

A. Some of the flood waters entering the Kill Van Kull had come from New York Bay on a previous ebb.

Q. And been subject to the pollution of New York Bay, had it?

A. Yes, that part had.

Q. What part had not?

A. The part which enters from the ocean directly and by far the larger part had not.

Q. How does it reach the Kill Van Kull from the ocean direct?

A. Through the Narrows.

Q. Jumps over New York Bay, does it, into the Kill Van Kull?

A. No.

Q. Well, does it pass through New York Bay?

A. Passes through the lower Bay.

4044 Q. Does it pass through the Upper Bay?

A. The lower portion passes through the Upper Bay, as I have stated.

Q. How much of that is it—that is the portion that comes through the Arthur Kill; how much is it?

A. What percentage of the total flood flow enters the Arthur Kill?

Q. Yes?

A. Well, if you want the exact figures, I shall have to get the Metropolitan Sewerage report. I will give my best judgment on the matter if you want it.

Q. I don't want your judgment; I want your recollection, if you have any?

A. About 81 per cent of the water flowing through the Kill Van Kull on the flood tide will come directly from the lower Bay, and the remainder will have come from the outer ocean by Sandy Hook.

Q. Well, now, the 81 per cent from the lower bay, by what course does it reach the Kill Van Kull?

A. Immediately around the shores of Staten Island.

Q. Through the New York Bay?

A. Through the Upper New York Bay.

Q. Through the Upper New York Bay. Why do you say it comes directly along the shore of Staten Island? How do you trace it so near Staten Island as that?

A. Well, because that is the channel, that is where the water runs.

Q. It is through the channel it comes, does it?

A. Yes.

Q. That is 81 per cent; and subjected, is it, or is it not, to the polluting influences of the waters of the Upper New York Bay?

A. Well, in so far as it is on that particular tide; on some previous tide that water may on some previous tide have been in part in the Upper Bay, but as it goes from the Lower Bay to the Kill Van Kull on the flood tide, all waters moving up are not at that time subjected to anything except some possible discharge along Staten Island.

Q. You think that the incoming flood tide comes in a fresh and unpolluted volume up the Kill Van Kull, do you?

4045 A. I would hardly call it either fresh or unpolluted, but I think I have stated what I mean. It comes without any influence.

Q. I will have to ask you to state it over again. Is the water flowing into the Kill Van Kull on the flood tide water that has been in the Upper New York Bay or not?

A. Well, in part it is.

Q. Well, to what extent is it water that had already been in the Upper New York Bay?

A. In order to answer that, I will have to trace it back through two or three days. I have told you what percentage came from the Lower Bay; now I will have to give you what percentage came from the Upper Bay on the previous tides. I can give you those figures. Of that 89 per cent of water which came from the Lower Bay into the Kill Van Kull on the flood tide, 83 per cent had been in the Upper Bay on the previous ebb tide; 7 per cent had been in the Hudson River on the previous ebb tide; 7 per cent had been in the East River on the previous ebb tide; and 1 per cent had been in the Kill Van Kull on the previous ebb tide.

Q. How do you account for that water being better than the water of the Upper New York Bay, then?

A. Largely because of the 19 per cent of water that had never been anywhere except in the ocean.

Q. And how had that 19 per cent reached the Kill Van Kull?

A. By flowing up on the flood tide through the Lower Bay.

Q. And then where?

A. Then through the lower part of the Upper Bay into the Kill Van Kull.

Q. So that the waters of the Kill Van Kull receiving the flood tides through the Upper New York Bay, in your opinion are higher and better in quality than the waters of the Upper New York Bay; is that so?

A. That expresses the act, but it is put in rather an unfortunate light.

Q. Now, the water that comes in by way of the Arthur Kill; what is the condition of that water, if you know, as to pollution?

A. The waters of the Arthur Kill—no, I don't know; that does not enter the problem. I have never given that any thought.

Q. Never examined the Arthur Kill?

A. No.

4046 Q. Do you know that the joint sewer outlet discharges at Elizabeth into the Arthur Kill?

A. I know there is a lot of sewage there.

Q. Do you know that the Arthur Kill is very highly polluted; do you know that, in a general way?

A. Yes.

Q. Do you think that the discharge of that water into the Kill Van Kull serves to refresh it?

A. No.

Q. How long is Newark Bay?

A. Nearly 10 miles, I should say.

Q. Newark Bay is nearly 10 miles long; do you think so?

A. I could tell you exactly if I had a good map; this map (indicating) does not show a very good scale.

Q. Have you never been on Newark Bay?

A. Yes.

Q. Don't you know that it is not 10 miles long?

A. No.

Q Never navigated it?

A. I have sailed up and down it, but I have never measured it.

Q. How far is Elizabeth from Newark?

A. I don't know; I am not a geographer.

Q. Well, you have been in that country, haven't you?

A. Oh, yes.

Q Well, have you no judgment as to the distance between Newark and Elizabeth?

A. Why, I suppose I could guess, if it was of value to you.

Q. No, I don't want you to guess?

A. Well, I have not any knowledge.

Q. Do you think it is 10 miles?

A. I don't know.

Q. I asked you whether you thought it was?

A. You said you did not want me to guess.

Q. I am asking you whether you think it is 10 miles?

A. I don't know; I don't think; I have not any idea how far it is.

Q. Well, do you think Newark Bay is 10 miles long?

A. Well, it looks to me on this map as though it might be 10 miles long.

Q. Well, looking back at your recollection of it, do you think it is 10 miles long?

A. I do not care to express any other opinion.

4047 Q. Do you think it is 2 miles long?

A. I said I thought it was 10 miles long.

Q. You said looking at that map you thought it was 10 miles long. Now, I ask you whether you really think it is 2 miles long, from what you know of it?

A. I don't know how long it is.

Q. Well, why do you say the conditions through the purification of the sewage in Newark Bay are superior to those in New York Bay; you said that?

A. Yes.

Q. Well, why do you say it?

A. Because of the possibilities of aeration which exist there, which do not exist to a corresponding extent in New York Bay, because of its greater depths.

Q. Well now, in what do the greater possibilities of aeration in Newark Bay depend?

A. A million gallons of water—any volume of water, exposed in a shallow depth will absorb oxygen from the atmosphere at a much greater rate than when exposed in deep depths. That rate is such a very important function of the depth that when we get to a depth of 20 or 40 feet the absorption on the bottom layers is practically nil.

Q. Has the surface of the water anything to do with the power of aeration?

A. It is entirely a surface function.

Q. Then does not the length of Newark Bay have some importance in determining the factor of aeration?

A. Not at all; it is merely the depth.

Q. Well, how do you arrive at the surface of a body of water; how do you reach a conclusion in figures as to the number of square feet in a surface of a body of water? You have got to know the length of the body, haven't you?

A. Yes.

Q. Well, do you know the length of Newark Bay?

A. No.

Q. Do you know the breadth of Newark Bay?

A. No.

Q. Do you know the area?

A. No.

Q. Has the area got anything to do with the power of aeration?

A. No, not per million gallons of water. I expressed my
4048 rates of aeration in the million gallon units. I don't care how big the area is.

Q. Where does the water get its dissolved oxygen?

A. It gets it originally from the atmosphere.

Q. It depends on the surface contact with the atmosphere, does it not?

A. Yes, and the falling of rains.

Q. And when you go below the surface, not having any contact with the atmosphere, there was no absorption, isn't that it?

A. No, that is not so.

Q. How does the absorption take place below the surface?

A. The layer next below the absorbing surface absorbs it from that; there is a migration of oxygen downward.

Q. There is a diffusion of the oxygen is that it?

A. That is it exactly.

Q. You do not mean to say the lower strata of water takes any oxygen directly from the air, do you?

A. No, I did not say that.

Q. Well, I asked you if you mean to be understood as saying it?

A. No.

Q. Did you express any opinion as to the condition of the river water at the mouth of the Passaic River?

A. I did not in my direct testimony. I would not be answerable for what I said, in cross.

Q. Why wouldn't you?

A. Because I have no recollection—being through so much.

Q. Well, have you any opinion as to the condition of the river water at the mouth of the Passaic River?

A. Yes, I have a distinct opinion.

Q. What is your opinion as to its condition with reference to oxygen?

A. On the ebb tide, when we are getting a real river water there

its condition with reference to oxygen is very low indeed, practically zero in the summer, and perhaps 30 to 50 per cent in winter. On the flood tide, of course, we have the Bay water there, which will improve conditions somewhat.

Q. Well, now, this river water on the ebb tide, by the time it has passed through the Newark Bay, has been raised a very considerable extent in oxygen, has it not?

A. Yes.

4049 Q. You don't know the distance?

A. No.

Q. Of travel?

A. No.

Q. If you discharged the same amount of sewage at Robbins Reef, untreated, how far would it have to travel, in your judgment, before it had become practically nullified in its effect upon the oxygen in the Upper New York Bay?

A. In the direct line, only counting one trip over, it would travel somewhere up above the upper limits of New York City, but it would actually make that trip some half dozen times before it got out of the Harbor; so that the actual distance travelled would be much longer than that.

Q. How long a distance is that?

A. Well, that looks like about 10 miles also on the map.

Q. 10 miles also on that map, yes; so that the same sewage discharged at Robbins Reef in New York Upper Bay, in your opinion, will travel before it reaches a point of stability equal to that of the river water of the Passaic River a distance of 10 miles, is that it?

A. That would be the actual stream distance covered, but it would vibrate back and forth in that period a long while.

Q. Does it vibrate back and forth in the Newark Bay a long while, or doesn't it?

A. Yes, I have no doubt it does about the same.

Q. Well, don't you know as a matter of fact that it vibrates longer?

A. No.

Q. Do you know anything about it as a matter of fact?

A. Yes.

Q. Well, what is the relative length of time of the final discharge of water, discharged into Newark Bay at the mouth of the Passaic River, before it reaches the Kill Van Kull?

A. I don't know that; I don't know how many tidal oscillations there are.

Q. Isn't it necessary in order to determine how long it will remain in the Newark Bay to know the number of tidal oscillations?

A. No, because I did not find it necessary to find how long it remained in Newark Bay.

4050 Q. Well, I thought you said you knew it would remain about as long there as it would in New York Bay, didn't you say so?

A. That is just my opinion, just now; I have not thought of that before.

Q. Well, now, if the sewage discharged from the Passaic River into Newark Bay is purified to the extent to which you testified, by the time it reaches the Kill Van Kull it happens that the distance is only about 3 miles, how do you account for the greater rapidity of purification in the Newark Bay as compared with what you believe will be the effect of the discharge into New York Bay of the same sewage, at Robbins Reef?

A. The shallower depth of water in Newark Bay is a very great aid to aeration. That is the only single factor that makes the work go on more rapidly there.

Q. And therefore it is safer and better means of sewage discharge to discharge it into shallow water than it is into deep water?

A. As far as the aeration is concerned, it is very much more desirable.

Q. Well, has dilution any part in the process of sewage disposal, in your opinion?

A. Yes, it has everything to do with it.

Q. Everything to do with it? Well, assuming the discharge of the same sewage in the same quantity at Robbins Reef as is now discharged at the mouth of the Passaic River into Newark Bay, do you think that the effect of that sewage will be as far-reaching in New York Upper Bay as it is in Newark Bay?

A. Yes, I think it will produce much more serious results.

Q. In what respect?

A. In respect of lowering the average dissolved oxygen contents of the water.

Q. Well, how will that happen when you take into consideration the much greater diluting power of the New York Bay?

A. Because the sewage, that would come to New York Bay as sewage, whereas it reaches Newark Bay, a large part of it after a long travel in the Passaic River, and has carried out a large part of its oxidizing reaction before it ever reaches the Bay. That is one effect. Another factor is———

4051 Q. (Interposing.) Well, I asked you to assume the same sewage?

A. Oh, assuming that that sewer discharged into Newark Bay?

Q. Yes?

A. Oh, I think that would do more harm in Newark Bay to discharge the sewage itself there at one point.

Q. Well, given the same condition of the discharge of treated sewage, do you think it is safer to discharge it into Newark Bay or New York Bay?

A. How treated?

Q. Treated in the same way; the effluent is to be the same effluent, the sewage being the same, and subjected to the same processes of treatment? Do you think it is safer to discharge sewage into Newark Bay or New York Bay?

A. Well, there are lots of processes of treatment; I don't know what you mean by the same process of treatment.

Q. You can assume any process of treatment that you see fit, only the effluent must have been the result from the same process?

A. Well, if it were purified on sand filters, it would not make any difference where it was discharged; it would not do any harm any way.

Q. Then the effluent would be harmless wherever it was discharged?

A. Practically.

Q. Suppose it was subjected to the treatment which will remove 10 per cent of the putrescible matter, measured on an absolute scale, do you think that that effluent could be more safely discharged into Newark Bay or into New York Bay?

A. I should think that would probably work more harm in Newark Bay.

Q. And why; why do you think that?

A. Because there would be the greater concentration of sewage there which would more than offset the greater oxidizing power of the Bay.

Q. Well, the greater oxidizing power of Newark Bay upon a given body of sewage results, does it not, from the fact that the percentage of surface is larger to the total contents than it is in New York Bay?

A. Exactly, yes.

4052 Q. And that in the ultimate oxidization of the sewage, that percentage is an important factor; that is all you mean by your testimony, isn't it?

A. Yes, exactly.

Q. And in your testimony, are you not assuming that it is important or necessary to oxidize all of the sewage discharge?

A. Well, sooner or later, that must take place, naturally.

Q. Well, so far as the problem of local influence is concerned, if the sewage is carried out to sea after a definite length of time, is it a matter of importance?

A. No, the problem ends there, if it gets out to sea and stays there.

Q. Well how long does it take for any particular body of water to be discharged from the upper New York Bay into the sea; how many tides?

A. Why, six or seven tides on the average, from the point opposite here.

Q. Now, if the sewage matter discharged into New York Bay, the Upper Bay, is held in suspension for the length of time necessary to discharge it into the ocean, what injury is going to be done by it?

A. It reduces the dissolved oxygen of the stream.

Q. Well, what importance has the dissolved oxygen, in your opinion?

A. The dissolved oxygen prevents the production of offensive conditions, odors, principally, and unsightly conditions, such as we have in the Passaic River.

Q. Well, in other words, it is important in taking care of sewage, is it not chiefly?

A. I would hardly state it that way; it is important in keeping the physical characteristics of the stream up to the standard.

Q. Well, now, what are those physical characteristics of the stream so far as they are applicable to Upper New York Bay which have an importance, except the digestion of sewage?

A. Why, the appearance is a very important matter. I don't think the Passaic River is a pretty thing to look at; it certainly would be a serious matter if New York Harbor got into that condition as to the appearance. The odors are an even stronger
4053 argument.

Q. Well, these conditions which you say are objectionable, and which are objectionable, do they arise in any other way than from the discharge of sewage?

A. No.

Q. And the dissolved oxygen, therefore, is important, is it not, in digesting the sewage which is discharged into the Bay, and chiefly for that?

A. I don't admit that point of view at all.

Q. Well, what else is of importance?

A. The sewage pollution reduces the dissolved oxygen, and the reduction of dissolved oxygen is coincident with nuisances in the stream. But I would not reverse the argument and say that the only advantage of dissolved oxygen was to purify sewage.

Q. Well, outside of being an indication of the presence of large quantities of sewage pollution in the waters what other important thing does the reduction of the dissolved oxygen in the water indicate?

A. That is all it indicates.

Q. That is all it indicates; and it is therefore a standard or scale showing the pollution of the water, is it not?

A. Yes, when properly interpreted.

Q. Well, outside of that function of sewage digestion or digestion of polluting matter in the waters, what other functions do you understand the dissolved oxygen has so far as the waters are concerned?

A. It supports fish life.

Q. What else?

A. A water which was devoid of dissolved oxygen—if one could conceive of that situation without sewage pollution, would be odorous of itself. The natural decay of organic matter, namely, vegetable life, within it would set up nuisance conditions.

Q. Well, that certainly would not continue for any considerable length of time, would it?

A. I think a water devoid of oxygen without any sewage pollution whatever would be a very unpleasant thing.

Q. At what point, do you think, in the reduction of oxygen will that occur?

A. Well, it would not be necessary to go clear out, but
4054 they get conditions in old cisterns where they used to store the roof water, where the fermentation of microscopic plants

and animals reduce the dissolved oxygen, and they get the characteristic, distinctly unpleasant odor of cistern water.

Q. Well, now, Professor, you have testified as to malodorous conditions, and what in your opinion will result on certain things being done on New York Harbor, and what are those things you believe would produce malodorous results on the shores of New York?

A. The specific chemical compounds?

Q. No, I am referring to your testimony that a discharge of certain sewage would result in malodorous conditions; do you remember testifying to that?

A. Yes.

Q. What was that sewage that you had in mind?

A. I had in mind the sewage as I conceive it will be constituted, that it is proposed to discharge at Robbins Reef Light.

Q. Well is that sewage treated or to be treated in any way?

A. Treated according to the proposal, by screening and sedimentation.

Q. And you have testified to having read the testimony of Mr. Johnson—George A. Johnson. You did read it I suppose?

A. Yes.

Q. You recall the fact that in his opinion that result will not be reached?

A. Yes.

Q. You don't agree with him?

A. No, I do not.

Q. That is all you mean to be understood as saying, isn't it?

A. Yes.

Q. You understand that the stipulation which is Complainants' exhibit No. 135 was adopted by the Government representatives, the United States Government representatives, including Mr. Black, or Colonel Black?

A. Yes.

Q. You understand that in his opinion the result will be the result guaranteed, do you?

Mr. O'Sullivan: That is objected to.

The Commissioner: Note the objection of Counsel for the Complainants.

4055 The Witness: *A.* No.

Q. You understand that he approved of those specifications in that stipulation, don't you?

A. Yes.

Q. And you do not understand that he believed that that result would be reached by the processes that are enumerated in that stipulation?

Mr. O'Sullivan: I object to Colonel Black's belief; it is not in issue here. It has been neither testified to nor put in issue in any way.

A. I know that Colonel Black's personal opinion is that that result will not be reached by these proposed works.

Q. And you know that, do you?
A. Yes.
Q. And nevertheless he was responsible—do you know he was responsible for this stipulation?
A. He was not supremely responsible, nor were the specifications that were finally adopted his original recommendations to the Secretary of War.
Q. Well, didn't he approve of them and recommend them?
A. Not in the form in which they were finally adopted.
Q. You are sure of that, are you?
A. Yes sir.
Q. What additional specification was there in Colonel Black's recommendation which is not in this stipulation?

Mr. O'Sullivan: Objected to.
The Commissioner: Note the objection.

A. His original recommendation contained a clause in addition to those that were finally accepted that the putrescibility of the sewage measured by certain specified standards should be reduced by a stated amount. I have forgotten the exact figure, but my recollection is 75 per cent before discharge.
Q. It should be reduced to 75 per cent?
A. Yes.
Q. Are you familiar with the stipulation in the Bronx Sewer Case?

A. Yes I am.

#656 Q. Do you remember how much that putrescibility was agreed to be reduced there?
A. There was a time-sliding scale there; I have forgotten the details of it. It started in rather light and got more and more severe.
Q. Well, what did it start in at?
A. I don't know.
Q. Don't you know it was 10 per cent?
A. I don't remember.
Q. Do you think that Colonel Black undertook to establish a 75 per cent reduction in putrescible matter?
A. That is the best of my recollection of his original report.
Q. Well, can the putrescibility of sewage be reduced 75 per cent?
A. Yes sir.
Q. By what process?
A. By filtration.
Q. What kind of filtration?
A. Through trickling filters.
Q. Well, when you testified as to malodorous conditions being produced by the sewage, did you have in mind the guarantees in the stipulation between the United States and the State of New Jersey as have the results guaranteed when discharged at Robbins Reef?
A. I had them in mind, but they do not influence me. They do not influence my mind as to what will happen.

Q. You are not influenced by them in any way?
A. No.
Q. You do not believe that an effluent can be produced that will have the results guaranteed when discharged at Ribbons Reef?
A. Not by the method that is proposed.
Q. Well, what method do you understand is proposed?
A. Screening and sedimentation.
Q. Nothing else?
A. That is all.
Q. How do you reach that conclusion?
A. That is in the stipulation.
Q. What else is in the stipulation?
A. That is all I recollect.
Q. You do not recognize any additional, lawful appliances or methods as having been contained in the stipulation?
A. There is that general clause, but it does not mean much.
4057 Q. It does not mean much?
A. No.
Q. Well, will you tell us why it does not mean much, in your opinion?
A. Because it is too indefinite. I don't know what a lawful appliance is.
Q. You are troubled with the interpretation of the word "lawful"?
A. Why, that in part, but the whole clause is exceedingly indefinite.
Q. Well, passing by the word "lawful" for the time being and assuming that the stipulation is that they shall introduce other appliances for purification, would that be too indefinite, in your opinion?
A. Yes.
Q. Why?
A. Because when these works are completed, and it is found out that they do not come up to the specifications, if that is the case, there seems to be no way provided in the contract by which anyone shall determine what other measures are necessary, and the whole thing is left in such an indefinite way it does not seem to me it can be enforced at all.
Q. Well, your doubt is as to the ability of the United States Government to enforce the stipulation, is that it?
A. Not of the United States Government, but my doubt is of the ability and the enforceability as to that contract as it reads.
Q. Well, have you any doubt that an effluent can be produced which will meet the guarantees of the stipulation?
A. Well, taken literally, I don't think an effluent could be so produced; but interpreted in a liberal way, I think those requirements can be essentially met.
Q. You said that there could be an effluent produced which would be safe to discharge anywhere, as I remember your testimony?
A. Yes.
Q. Well, don't you think that effluent which you have said could

safely be discharged anywhere could produce the guaranteed results if discharged at Robbins Reef?

A. Those results are pretty fine. An effluent which would be safe to discharge anywhere, for example, might contain some suspended matter, visible suspended particles, but this guaranteed result states that the effluent shall not contain any visible suspended particles.

4058 Q. Taken in the liberal sense, then, if you want to distinguish, do you think an effluent can be produced which could result in the guaranteed results?

A. Yes, undoubtedly.

Q. What processes do you think will be necessary to apply to the sewage which are not particularly described in the stipulation in question?

A. I don't think anything less than a sand filter would come at all within the stipulation.

Q. Yes, well, that is feasible, isn't it?

A. I hardly want to say that it is feasible; it would be a tremendous undertaking. Of course it could be done.

Q. It could be done?

A. But hardly feasible from an engineering standpoint.

Q. But could it be done?

A. It could be done.

Q. Well, having been undertaken to produce the effluent by the means described or by other lawful appliances do you have any doubt that that is a lawful appliance?

A. I suppose a sand filter is a lawful appliance.

Q. What in your opinion, is the difficulty then, with the United States Government enforcing its stipulation against the State of New Jersey?

A. There is merely the very great difference between what is conceivably possible and what is feasible or practical from an engineering point of view. It would bankrupt the communities, and they could not do it.

Q. Well, Professor Phelps, do you think it is desirable to continue the discharge of the sewage into the Passaic River?

A. No, not at all.

Q. What is going to be done with it?

A. Why, my solution would be for each to solve their own problem. Purification methods are available by which they could get out of it a lot cheaper than down at Newark.

Q. That is a question of economy, is it not?

A. Yes, entirely of economy.

Q. The same processes that would produce effluents that could be discharged into the immediate streams of the municipalities, when applied to the general sewage collected on the Newark
4059 Meadows would produce an effluent which would be discharged into the Newark Bay?

A. Well, the problem is complicated by the age of the sewage, but practically that is so.

Q. Complicated by the additional age of the sewage. Do you think it is even more economic to establish separate disposal plants than to have a combination one?

A. Very much so.

Q. You find that so in actual practice, do you?

A. Yes sir.

Q. Why?

A. Because in the first place it saves a very heavy expense, and interest charges on a trunk sewer. In the second place it is possible to find small places adapted for sewage disposal, where it is not always easy to find large ones. Your nuisances are always lessened on a small plant.

Q. Well, you are familiar with the territory of the Passaic Valley, are you?

A. I am not very familiar with that country, no.

Q. You have been up and down the Passaic River?

A. Yes.

Q. And Newark Bay?

A. Yes.

Q. Where is the place that you selected for the City of Newark?

A. I have not considered that matter in sufficient detail to decide.

Q. Well, you know that a very large percentage of the sewage is produced in the City of Newark, don't you?

A. Yes, I understand that is the case.

Q. And you recognize the necessity of giving that some treatment?

A. I certainly do. Although that is the least important of the lot.

Q. That is the least important, is it?

A. Because they have the Bay to discharge into.

Q. What Bay have they to discharge it into?

A. Newark Bay.

Q. Do you think they could safely discharge their sewage into Newark Bay?

A. I think they could for some time to come without producing serious nuisance.

Q. And still you think the additional discharge of the sewage of the Passaic Valley above that contributed by the City of Newark into New York Bay would create a nuisance, do you?

4060 A. Taken on top of what we have now, it would certainly do so; it would not alone.

Q. The trouble with New York Bay, in your opinion, is what New York City is doing, is it?

A. It is the present condition.

Q. And New York City has practically rendered the waters of New York Bay a nuisance, has it not?

A. Practically, yes sir, in conjunction with other cities that have taken part in it.

Q. Well, you think that the discharge of the effluent from the works as described in the stipulation at Robbins Reef will be per-

captible in the face of and under the conditions of nuisance that have already been created by New York City?

A. Yes sir, very distinctly.

Q. How, and where?

A. By greater reduction in dissolved oxygen in all parts of the lower Harbor and Hudson and East Rivers.

Q. Well, in what other respects?

A. Greater evolution of offensive gases, and general unpleasant appearance of the waters.

Q. Did you say how much you thought the oxygen in the New York Bay would be reduced by the discharge of the sewage of the Passaic Valley?

A. I have estimated that in the Upper Bay it would be reduced to 40 per cent.

Q. It would be reduced to 40 per cent?

A. Yes.

Q. What is the actual reduction that you figure on by the introduction of this sewage at Robbins Reef?

A. About 25 on the average.

Q. 25 per cent?

A. It is from 65 to 40.

Q. Well, assuming saturation, what would be the reduction, in your opinion, from the introduction of the Passaic Valley Trunk Sewer at Robbins Reef, treated as described in the stipulation?

A. You mean assuming that the water was saturated at the start?

Q. Yes?

A. About the same amount.

Q. About 25 per cent?

A. Yes.

Q. If one of the witnesses for the Complainants has testified that in his opinion the reduction would be 7 per cent, you do not agree with him?

A. No, not at all.

Q. You know that a witness did testify to that, do you not?

4961 A. No, I do not know that.

Q. What is the amount that you are figuring on as to the quantity of sewage?

A. That is the ultimate amount.

Q. 360 million gallons per day?

A. Yes.

Q. How much sewage is discharged into New York Bay at the present time from the City of New York?

A. I have kept that in terms of population; I cannot give it in gallons but figuring on contributing population of about 4,000,000 people.

Q. That is the present contributing population?

A. Yes.

Q. Do you know what the present contributing population of the Passaic Valley is?

A. I have not those figures in mind.

Q. What is the ultimate contributing population which is to produce this 360 million gallons, if you understand it?

A. Between 2 and 3 millions, I understand it.

Q. 2 or 3 million people in 20 years in the Passaic Valley; you understand that to be the estimate do you?

A. Yes.

Q. Would you have to revise your figures if the estimate is 1,500,000?

A. I have a habit of making my calculations on actual population, and not on sewage flow, and I am trying to convert my sewage flow into population. I have not those figures very clearly in mind.

Q. Well, given three times the population in New York City—three times the population as is estimated to produce 360 million gallons of sewage, and discharging that directly into New York Bay, what in your opinion will be the reduction in the oxygen contents or dissolved oxygen of that sewage? Would it be three times that you estimate from the Passaic Valley?

Mr. O'Sullivan: When?

Mr. Riker: At any time.

A. I don't quite catch your meaning, given three times what estimate?

Q. If the population of the City of New York at the
4062 present time is three times the estimated population of the Passaic Valley 20 years from now, is there any reason why the reduction of free oxygen in the waters of Upper New York Bay should not be three times the amount that you have estimated for the discharge of 360 million gallons of sewage from the Passaic Valley?

A. Yes, a very great reason.

Q. What is the reason?

A. That reduction of dissolved oxygen is not such a simple direct ratio as you have indicated. The additional application of sewage to the water depresses the oxygen level and that depression calls for increased aeration, so that continuous addition of population makes a less proportionate reduction in dissolved oxygen. That is, theoretically we never could get it all down, there would always be some aeration which would be a factor, and there would always be some oxygen.

Q. Well, in other words, a discharge of 360 millions of gallons of sewage from the Passaic Valley, in your opinion, will reduce the oxygen contents 25 per cent, and the discharge of the sewage from three times the population living in New York City will not reduce it any more, is that it?

A. No, it will reduce it a good deal more, but not three times as much.

Q. Well, how much will it reduce it, or ought it to reduce it if the reduction in the Passaic Valley sewage under those conditions is 25 per cent, and how much in your opinion ought the discharge from three times the population living in New York City reduce it?

A. It is a very elaborate computation to figure what that would be.

Q. I don't want it exactly; give me an approximation?

A. I have made some computations here (indicating) for certain populations. We have some computations here based on an assumed population of 4½ millions, which is very close to your question, and it gives us in various parts of the Harbor oxygen saturations of from 40 to 75 per cent.

Q. Those are actual determinations, are they not?

A. No, those are all computations; they agree fairly closely, however, with the determined values.

4063 Q. Where was the reductions to 40 found?

A. 40 was in the Harlem River.

Q. Well, have you got any in the Gowanus Canal also there?

A. No.

Q. Where is the 75 or whatever you say it was?

A. 75 is in the Upper Bay, on the flood.

Q. And you say that the introduction of the 360 millions of gallons of sewage of the Passaic Valley at Robbins Reef will reduce the average oxygen contents in the Harbor 25 per cent?

A. In the Upper Bay.

Q. In the Upper Bay?

A. Yes.

Q. That is the sewage of the 4 million and a half population of New York City will reduce the average oxygen contents 25 per cent in the Upper Bay?

A. Almost exactly, yes.

Q. Well, how do you account for the fact that three times the population only reduced the average oxygen contents the same amount?

A. The sewage that we have calculated or estimated here is distributed all about these waters, largely in the East River, and considerable portion of it goes out through Long Island Sound, and has a very much greater dilution factor than would be obtained by discharging at Robbins Reef. The computations are made on exactly the same assumptions as formerly.

Q. How much of the sewage goes out through the Long Island Sound?

A. This is a little complicated. I will try to give it to you. About 20 per cent of all the sewage which reaches the area betwen Hell Gate and Throggs Neck. That includes the drainage of all the Flushing area, and a large portion of the flow of the Harlem River leaves the river into the Sound at the end of the ebb tide and about 50 per cent of the sewage which is discharged into the East River between the Battery and Hell Gate gets into that area I first mentioned during the ebb tide, so that 20 per cent of that 50 per cent is discharged on the next ebb.

Q. So that in your opinion so far as the general condition of the Harbor or Upper New York Bay is concerned, it is rather advantageous to discharge the sewage as it is now being discharged right

along the shores as compared with discharging it out into
4064 the deep water at Robbins Reef, for instance?

A. I would not care to be responsible for that opinion, no, sir.

Q. Well, doesn't that explain the fact that three times the amount of population only produces a reduction in oxygen that you have estimated from the discharge of the Passaic Valley sewage at Robbins Reef?

A. No, I do not think you have got the point at all.

Q. Well, will you explain the point, Professor?

A. The particular point is that instead of discharging the sewage all at one spot, at a place where it will be carried up into the weakest part of the system, namely, the lower Hudson River, under the present conditions it is discharged at hundreds of outlets, and is diluted into the tidal water at each tide, also at such points that a considerable portion of it gets out through Long Island Sound, or subjected to the purifying action of fresh water coming in from Long Island Sound. It is that general distribution of the sewage all about the system rather than putting it into one spot that produces that effect.

Q. And you are bearing in mind that there has been some reduction in putrescibility by the treatment that is to be given to the Passaic Valley sewage as you understand the stipulation?

A. Why, I testified that I don't think that reduction will materialize.

Q. You don't think there will be any reduction?

A. No.

Q. You don't think that the reduction of the suspended matters by sedimentation will reduce the putrescible matter at all?

A. No.

Q. Did I understand you rightly?

A. That is correct.

Q. Is there anybody that agrees with you in that position, that you know of?

A. I don't recall having discussed it with anyone.

Q. And you are not, therefore, assuming that there will be any removable of putrescible matter by the disposal specifically described in the stipulation in question?

A. I have tried to make that point clear in my testimony.

4065 Q. Well, answer it again then?

A. I will. I would distinguish between the removal of putrescible matter and the removal of putrescibility. There will be a removal of material there, but as I explained, there will be a compensating increase in putrescibility in what is left, which, judging by experiences elsewhere, will more than make up for that removal.

Q. And therefore, in your opinion, the effect of the sewage from the Passaic Valley sewer will be as great in the reduction of Oxygen in the waters of Upper New York Bay as the discharge of the sewage from the whole population of the Greater City of New York?

A. As that affects the Upper New York Bay, yes, sir.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Professor Phelps, you mentioned in relation to New York City's sewage that it was discharged at a number of points. I ask you whether that sewage is fresh, stale or septic at the time of its discharge?

A. It is exceedingly fresh.

Q. Is the consumption of oxygen by fresh sewage or by septic sewage greatest?

A. By septic sewage it is much greater.

Q. Which is the more rapid?

A. Septic sewage, old sewage.

Q. Is it a universal experience among sewage disposal operators that sewage is more economically and effectively treated near its source or origin?

A. That I think is the universal belief.

Q. Do you know of anyone who has proclaimed any different condition as the result of sewage treatment?

A. I have never heard of any.

Q. The sewage that you have been testifying to as proposed to be discharged by the Passaic Valley trunk sewer at Robbins Reef, at or near Robbins Reef Light, what condition will you expect that sewage to be in at the time of its discharge?

A. I should expect it to be distinctly septic without any dissolved oxygen, very much decomposed, broken up into fine material, black in color, and very malodorous.

4066 Q. When sewage is macerated by long transit and pumping, and attritions in a long sewer of transportation are the organic matters largely put into a condition to enter solution readily or not?

A. They are to a large extent actully dissolved, and where they are not dissolved the- are rendered colloidal in nature. It is a semi-dissolved condition. In general they are rendered more readily oxidizable.

Q. Are they easily removed in that condition by sedimentation or screening?

A. No, they are not removed with any degree of efficiency whatever.

Q. What is the difference in the method of oxygen consumption by fresh sewage through biological agencies and septic sewage?

A. The difference is mainly one of rate of reaction. A septic sewage has been brought to a physical and chemical condition, where it is exceedingly active in its bio-chemical reactions and it is oxidized with much greater rapidity when brought into contact with oxygen than would be the case with the corresponding fresh sewage.

Q. When substances enter into combination with oxygen through chemical agencies, direct, and through biological agencies indirect, which is the more rapid process and which process will exhaust the oxygen content of the water into which such substances are discharged most rapidly?

A. The bio-chemical reactions are generally much more slower than direct chemical reaction, and in the case under discussion what

direct chemical reaction might take place would do so with very great rapidity. Hydrogen sulphide, for instance, would be oxidized directly by the oxygen of the water, and would result in an almost immediate reduction of dissolved oxygen.

Q. And after the oxygen content was reduced considerably then would the hydrogen sulphide escape into the air?

A. Well, that portion which had been oxidized would not.

Q. The un-oxidized?

A. The reduction of the dissolved oxygen would lead to a still greater production of hydrogen sulphide due to the anærobic conditions established.

4067 Q. Is hydrogen sulphide the product of ærobic or anærobic functional activity?

A. Anærobic.

Q. When sewage is transported in a long trunk sewer, does that favor or disfavor anærobic action?

A. That favors it.

Q. Favors which?

A. Anærobic action.

Q. Mr. Riker asked you questions relative to the volume of New York City sewage. Did you take into consideration in estimating the measure of pollution of New York's Upper Bay the amount contributed by the riparian cities in New York Bay to that pollution, as well as the amount of pollution contributed by New York City?

A. I think that figure of practically 4½ millions was a contributing population to the particular bodies of water that we have under discussion. Of course there is a considerable contributing population within the boundaries of New York City that do not contribute to this Bay.

Q. What cities in the State of New Jersey are riparian and contribute sewage to New York Upper Bay?

A. I shall have to stop at Hackensack; I don't know anything about that. There is Hackensack and Bayonne.

Q. Hoboken?

A. Hoboken, yes.

Q. In estimating the ultimate capacity of the trunk sewer at 360 million gallons of sewage a day you mentioned in reply to a question put to you by Mr. Riker that you had found that a volume of sewage contributed by the silk factories of Paterson had been eliminated from the computation of sewage and trade wastes to be carried in the sewers. What did you estimate the per capita of that item of sewage alone which had been eliminated to equal?

A. 200 gallons per capita per day for the entire population of Paterson.

Q. And they had failed to take that into consideration, had they?

A. That I understand is not included in the 360 millions.

Q. In answering questions of Mr. Riker on the condition of the Passaic River and its oscillations, do you regard the Passaic River as a septic tank?

A. Yes, sir; in the summer time I think that is a very fair

4068 name for it.

Q. What is a septic tank?

A. A septic tank is ordinarily a basin or tank in which sewage is held, and in which certain reactions, sedimentation, and biological reactions are allowed to take place. The flow through the tank is slow, and in that respect the Passaic River would not be an ideal septic tank, but in that river owing to the tidal backing up the flow is sufficiently stagnant or slow to allow sedimentation to take place and so we have the activities and reactions that would occur normally in a septic tank.

Q. Is that a purifying process for the sewage?

A. In one sense it is. In the sense that it is a step in the direction of purification, it is. But in the other sense if we consider the effluent from such a treatment directly, it is more offensive and in a much worse condition than fresh sewage.

Q. Well, carrying the simile along, do you regard the effluent which would gradually drift into Newark Bay as one which would be more readily oxidized in a shallow basin right near Newark Bay than if it had originally been discharged there instead of into the river?

A. Yes.

Q. Are shallow bodies of water more readily ærated and more affected by the wind in æration processes than deeper bodies of water?

A. They are, very much.

Q. Irrespective of the areas of such bodies?

A. Yes, sir.

Q. Mr. Riker directed your attention to Complainants' Exhibit No. 135, Professor Phelps; have you studied the guaranteed results of the effluent proposed to be discharged at Robbins Reef?

A. Yes, sir.

Q. Do you believe it possible to secure such an effluent with the current described in that stipulation?

A. No, I do not.

Mr. O'Sullivan: I think that is all.

Recross-examination by Mr. Riker:

Q. Professor, do you think it is possible to produce an
4069 effluent which will result in the guaranteed results of the stipulation, Complainants' Exhibit No. 135?

A. Yes.

Q. Are you familiar with the disposal plants of Hamburg, Dresden and Frankfort?

A. Not from any personal observation.

Q. Do you know how far from the respective cities the disposal plants are located?

A. No, I do not.

Q. Do you know whether the sewage treated in those disposal plants is septic or not?

A. No.

Q. You know they have disposal plants, I suppose?

A. Why, at Hamburg they screen the sewage and I guess that is

all they do to it. I don't think they settle it. What are the other places, Berlin?

Q. Dresden?

A. I don't know about Dresden.

Q. Frankfort?

A. At Frankfort they have—they settle the sewage at Frankfort, screen it and settle it.

Q. And you do not know how far from the cities those plants are located?

A. No.

Q. You do not know whether they are as near or further away than the proposed disposal plant from the Passaic Valley with reference to the City of Newark?

A. No, I do not.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Do you know that sewage is fresh that is treated at all these three points?

A. I am most familiar with the Hamburg work, and I know that that is quite fresh, because the actual removal of material there includes a great deal of fecal matter which would be impossible in stale sewage. I am not sure about the other cases.

Mr. O'Sullivan: That is all.

Mr. Riker: That is all.

Adojurned to June 4th, 1913, at 10:30 A. M.

4070 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Before James D. Maher, Esq., Commissioner.

NEW YORK CITY, June 4th, 1913—10:30 a. m.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

HARRISON PRESCOTT EDDY, a witness in behalf of the Complainants, recalled in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Mr. Eddy?
A. Harrison Prescott Eddy.
Q. You testified in this suit previously?
A. I have, yes sir.
Q. Mr. Eddy, has your attention been directed to the testimony given by Mr. George A. Johnson, for the defendants, and as to that part appearing on page 3976 to and including pages 4010 and 4011?
A. It has, yes sir.

Q. Have you made a direct observation on sewage outfalls
4071 from submerged outlets, as to what becomes of the sewage?
A. I have, yes sir.
Q. Where?
A. I have made a number of such observations in Boston Harbor.
Q. How many sewerage districts are there discharging into Boston Harbor?
A. Three main districts.
Q. What are they?

Mr. Riker: The question is objected to on the ground that it is not rebuttal. It has been admitted and put into the record dozens of times that there are three outlets in Boston Harbor; it has not been controverted by anybody.
The Commissioner: Note the objection of Counsel for the defendants.

A. The outlet of the Boston main drainage works at Moon Island; the outlet of the North Metropolitan Sewerage Works in the vicinity

of Deer Island Light; the outlet of the South Metropolitan Sewerage Works in the vicinity of Peddock's Island, sometimes called the Nutt Island outlet.

Q. Which is the oldest of these plants?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The Boston Main Drainage Works.

Q. How is that discharged?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. The sewage is retained in large storage reservoirs for a period of about 10 hours during the day, and during the incoming tide and part of the out-going tides. It is discharged twice daily, the discharge being made in the vicinity of the turn in the tide, so that the sewage discharged goes out on the outgoing tide. The discharge usually lasts about two hours after the turn of the tide.

Mr. Riker: Counsel for Defendants desires to ask counsel for the Complainants for what purpose these undisputed facts are again put upon the record.

4072 Mr. O'Sullivan: Counsel for Complainants, in reply would state that it does not make any material difference whether the discharge is at the surface, as is now being described by the witness, or from a submerged discharge of 30 feet, similar to the one proposed by the Passaic Valley Commission, and that in each and every case the sewage rises to the surface, and it gets no greater diffusion or dispersion by the proposed method of discharge of the Passaic Valley Sewerage Commission.

Mr. Riker: Counsel for Defendants again asks why it is necessary to put undisputed facts upon the record, a multiplicity of times for the purpose you have now indicated?

Mr. O'Sullivan: To avoid any confusion as to the ones that will be later discussed by this witness, it is necessary to show he is familiar with the method of discharge from each of the three systems before he discusses the one that is absolutely pertinent to the dye experiments to be refuted here.

Mr. Riker: That is not rebuttal.

Q. Mr. Eddy, where does the North Metropolitan Sewerage Works discharge?

Mr. Riker: The question is objected to upon the ground that this matter is already upon the record at least a dozen times and is not disputed, and is an admitted fact as to where it is discharged; and counsel is abusing the privilege of this examination by putting this question to this witness on rebuttal.

The Commissioner: Note the objection of Counsel for the Defendants.

A. The centre of the Deer Island Light.

Q. Is that the submerged outfall?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. It is.
Q. Where does the South Metropolitan Sewerage Works discharge?

4073 Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. About a mile and an eighth in a general northerly direction from Nutt Island, and about half a mile westerly from Peddock's Island.
Q. Is that a submerged outlet?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. That is a submerged outlet.
Q. Submerged to what depth?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. At low water it is at a depth of about 30 feet, at high water about 40 feet. This refers to the more easterly of the two outlets, the northerly outlet is submerged to 24 feet at low water, and to 34 feet at high water.
Q. Are both of these in use?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. Under ordinary conditions, only the more easterly of the outlets is used. The westerly outlet is used at times of extremely high flow in sewers.
Q. What population is served by the South Metropolitan System?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. About 250,000.
Q. Have you observed the discharge of sewage from the Moon Island Outlet?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I have, many times.
Q. Have you observed the discharge at the Deer Island Outlet?

4074 Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I have on many occasions.
Q. What were your observations as to the effect of the sewage discharged from that outlet?

Mr. Riker: The same objection, and also by the fact that he has already testified on direct examination to this very question.
The Commissioner: Note the objection.

A. The sewage from this outlet comes immediately to the surface, forms a large sewage field, and a large sleek field. At times the sewage is very offensive, and is always, so far as my observation goes, easily detected, and covers a large area.

Q. Extending in length for about how far?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. When I sailed through the area last August, 1912, I estimated the length of the sewage field to be over a mile. The water was highly colored, dark brown in color, and was exceedingly offensive around and for some distance from the outlet. The odors were easily distinguished from the boat.

Q. What were the odors; how would you describe them?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Greasy sewage odor, which was offensive.

Q. Have you made observations at the Nutt Island outlet?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Q. I have on a number of instances, particularly on the 28th of July, 1911, on the 13th of September, 1911, on the 29th of May 1913, and on the 31st of May 1913.

4075 Q. Will you describe the Nutt Island outlet, its submergence and its comparable conditions with those proposed by the Passaic Valley Sewerage Commissioners?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The Nutt Island outlet is located in a northerly direction from the Nutt Island screen house to which all the sewage gravitates, and where the sewage is roughly screened. From this screen house the sewage passes through a cast iron submerged outfall pipe about 60 inches in diameter to the more easterly outlet, a distance 5,830 feet. This outlet is placed at or near the bottom of the Bay, and at low water is submerged to a depth of 30 feet. The outlet pipe is 50 inches in diameter.

Q. I see you consulting a blueprint, Mr. Eddy; what does that blueprint represent?

A. This (indicating) is a blueprint made up in my office under my immediate direction and oversight, and contains data and sketches taken from two record plans of Section 43 of the South Metropolitan Sewerage Works, Numbered sheets 1 and 2, dated November, 1904, and signed by William M. Brown, Engineer of the Sewerage Works.

Q. Who is William M. Brown?

A. He was at that time Engineer of the Sewerage Works.

Q. Do you know what he is now?

Mr. Riker: The question is objected to on the ground that it appears on the records by the same witness who Mr. Brown is.
The Commissioner: Note the objection.

A. Engineer of the Passaic Valley Sewerage Works.

Mr. O'Sullivan: I offer the blueprint described by this witness representing outfall pipes, the high level sewer of the South Metropolitan Sewerage Works, in evidence, and ask that it be marked Complainants' Exhibit No. 206.
Mr. Riker: The offer is objected to on the ground that the proposed exhibit has not even had the first element necessary
4076 for its introduction proved.
The Commissioner: Note the objection.
Received in evidence and marked Exhibit No. 206.

Q. Did you perform any dye experiments at the Nutt Island outlet, and with the sewage discharged through the Nutt Island outfall?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence introduced on the part of the defendants and should have been introduced in his main case if it is competent at all.
The Commissioner: Note the objection of Counsel for the defendant.

A. Yes.
Q. When did you perform these experiments, Mr. Eddy?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. One in July, 1911.
Q. What day in July?
A. What date?
Q. What date?
A. July 28th, 1911; two on the 29th of May 1913, and I was present when similar experiments were made on the 31st of June, 1913.
Q. Did you say June or May?
A. May I should have said.
Q. Will you describe the experiment of July 28th, 1911?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. On this date, in company with my partner, Leonard Metcalf, and an assistant, W. L. Butcher, and Professor Bonnett of the Worcester Polytechnic Institute, I took a tug in Boston Harbor, and sailed down to Deer Island, thence to Nutt Island. On that day there was an extremely high wind, and the very heavy downpour of rain lasting throughout our trip on the Bay. At Nutt Island I procured a barrel and saw that it was filled with water

and the two pounds of eosine blue dye were introduced into
4077 the barrel and thoroughly mixed. At a specified time this dye was turned into the sewer, and I sailed to the outlet, and at the computed time or very close to it, I observed the dye coming from the outlet and easily visible on the surface of the Bay. At the same time there were large quantities of sewage matter, paper, fecal matter, fruit skins, matches and the general turbidity and discolor which goes with the sewer in the vicinity of the outlet. The water was extremely rough, so that there was a very good opportunity for mixing, diffusion and dilution of the sewage, but instead of this fact it was clearly discernible from the deck of the tug on which I was sailing. At about 10 minutes after the dye had been seen at the outlet, the area covered by the sewage field was in the neighborhood of 400 feet square. About 20 minutes after the dye had been first observed, the sewage field was approximately 1,200 feet long by 1,000 feet wide, and the color was faded. At 2.19 or about 30 minutes after I first observed the dye, the color had disappeared, and the visible sewage field as distinguished from the sleek field covered an area about 400 feet in diameter. Just as I was about to leave the street washings due to the storm reached the outlet and created a very large sewage field very much discolored being a very dark, dirty brown. This field could be seen for a considerable distance, I should say at least a quarter of a mile from the outlet.

Q. How deep was the submerged point of discharge on that occasion for both the sewage and the dye?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

The Witness: At that time the outlet was at about the depth of 30 feet below the surface of the water, high tide, according to the Government records, being at 1.20 P. M., and the observation of the dye being at 1.49 P. M., just about 30 minutes after high tide.

Q. Did you say 30 or 40 feet?
A. I should have said 40 feet.
4078 Q. Now, as to the experiment on September 13th, 1911, with dyes; will you describe that?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. On September 13th, I took a small launch in the morning in company with Doctor Parsons, then in the employ of the Metropolitan Sewerage Commission. We sailed down to the Deer Island outlet, then across to Nutt Island. The day was overcast, although it did not rain, and there was a high wind. On this day I did not add dye to the sewage, but observed the sewage matter coming to the surface in the vicinity of the outlet from Nutt Island. There was a marked and easily distinguishable sewage field and the usual sleek field in the vicinity. I distinguished the sewage field by the color, the dirty appearance of the water, and by the paper and fecal matter, fruit skins, etc., which I could observe in the water.

Q. Will you describe how the sewage came to the surface, as you noticed it?

Mr. Riker: The same objection?
The Commissioner: Note the objection.

A. The sewage came to the surface in the form of a spring, in a pool of water, that is, you could distinguish the movement of the water, the current, the upward current, as it came to the surface and was then spread out laterally in the bay.
Q. Was it higher, the sewage surface, than the surrounding water immediately over the outlet?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. It was slightly high, yes sir.
Q. As to the experiments of May 29th, 1913, will you describe them, Mr. Eddy?

Mr. Riker: The same objection.
4679 The Commissioner: Note the objection.

A. On May 29th, low water, by the Government record occurred at 12:28. At 11:37 I visited the Nutt Island screening station and made preparations for the application of two portions of eosine blue dye. The first portion was of two pounds weight and the second portion a quarter of a pound weight. The two pound package was dissolved into the barrel of water and turned into the sewer at 12:15. The quarter pound package was dissolved in the same quantity of water and poured into the sewer at 12:30. At 12:34½ I observed the two pound dose of dye at the outlet, just 19½ minutes after it had been applied in the screen chamber. At 12:51½, or 21½ minutes after the quarter pound of dye had been applied in the screen house, I observed the colored water in the outlet resulting from that application of dye. On this occasion I visited the outlet in company with W. L. Butcher of my office force and Mr. Grant accompanied us as far as the Nutt Island screen house. We went to the outlet in an open motor boat about 25 feet in length. The wind was quite fresh so that we had shipped considerable water getting to the outlet, but after we got to the outlet, the sleek formed by the grease from the sewage covered a large field, and stilled the water so that we had no difficulty in cruising about within the sewage field. On this day the sewage field could be easily distinguished from the screening station a distance of about 1⅛ miles from the outlet. This was doubtless due in part at least to the storm water, there having been more or less rain the night before, which gave to the sewage a brown and dirty appearance. The sewage appeared to extend northerly to the shore of Peddock's Island, a distance of about a half mile, and in width at the point nearest the island where I sailed through it, I should say it was at least 1,200 feet. It was a very dirty field containing large quantities of paper, fecal matter and matches, strips of grease, which could be easily distinguished as of sewage origin. The dye in both experi-

2769

ments could very easily be distinguished by its pink color.
4080 It was doubtless more easily distinguished because of the rough water and where the waves broke on the windward side of the sewage field, the pink spray was very easily distinguished. I think the dye could be more easily seen under those conditions than in quiet water.

Q. How deep was the point of discharge during these experiments of May 29th, 1913?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. About 30 feet below the surface.

Q. Now, as to the experiments on May 31, 1913; will you please describe them?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. On this day I was present although the experiments were made by Professor Sedgwick. I was present in the boat which was this same motor boat that I used on the 29th. I visited the Nutt Island screen house, and saw the preparations made for admitting the dye, and my assistant Mr. Weber was left in charge of that work with instructions as to when the dye should be introduced. I was present at the outfall, and saw the dye, and saw the condition of the sewage field and sewage sleek.

Q. How deep is the point of the outlet for the sewage that is discharged from the Treatment Works at Providence, Rhode Island?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. About 25 feet.

Q. Did you make any observations of that sewage discharged from the Treatment works, at Providence, Rhode Island?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I have.
4081 Q. Will you state when and describe what your observations consisted in?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I visited this outlet in the spring of the year of I think 1912, took a rowboat in company with Mr. Julius W. Bugby, who is in charge of the Providence sewage treatment plant, and rowed out through and around the sewage field over the outlet from the sewage treatment works. At that time the quantity of sewage treated was about 20 million gallons per day. The treatment consisted of screening and sedimentation in very large settling basins, together with the application to the sewage of bleaching powder. At the sewage outlet the sewage field could easily be distinguished, the sewage could be

seen as it came to the surface and spread out over the water in Providence River.

Q. How would the treatment that you have just described compare with the treatment proposed by the Passaic Valley Sewerage Commission for the sewage contemplated to be discharged at Robbins Reef?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I think it would be just as efficient.
Q. How deep was the point of discharge, Mr. Eddy?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. About 25 feet.
Q. Was there any difficulty in detecting the sewage field and the sewage as it came to the surface?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. There was not.
Q. Mr. Eddy, directing your attention again to the testimony given by Mr. George A. Johnson at the pages which have been
4082 previously referred to, and handing you Complainants' exhibit No. 205, I ask you if you find in that exhibit any reasons for the matters testified to by Mr. Johnson, and for the opinions you have expressed in relation to the disposal of that sewage after its discharge?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence offered on behalf of the defence, the proper rebuttal requiring the direction of the witness to some specific testimony on behalf of the defence.
The Commissioner: Note the objection of Counsel for the defendants.

A. With reference to the first part of the question, some of the testimony of Mr. Johnson stated that the coloring matter introduced was carried to the surface, and I think that there are reasons due to the configuration of the channel which would tend to carry that dye to the surface of the water. The channel is not as deep in the vicinity of the outlet as it is down stream or up stream from that point, so that there would be a tendency for the incoming current to be carried toward the surface, and a similar tendency for the outgoing current to be carried to the surface. This tendency will cause the sewage to be carried to the surface, and very likely that condition existed at the time of those experiments. Part of his experiments were not successful in his being able to observe the dye, in other words the dye was not observed. I think that this same condition may account for that, in that the current produced was carried so far from the point of application that he did not observe the dye; in other words did not look at the right place for it, which is a thing

which is very easy to occur under such conditions. With respect to the latter part of the question, referring to my own opinion, I think that the configuration of the channel is such that the sewage will come to the surface and that it will be carried along in a body when it forms a sewage field. The channel at the Narrows is very
4083 narrow: It widens out to perhaps twice its width at the Robbins Reef and holds out something like this width almost all the way up to the Battery. So that, a large sewage field, formed in the vicinity of Robbins Reef light would be likely to be carried as in a river or stream, and would not have the tendency to spread out that it would in a very large bay of water subject to greater wind action.

Q. From your studies of the testimony given in relation to dye experiments performed by Mr. Johnson, and from your own observations of the dye experiments performed by you in Boston Harbor, and from your observations of the sewage discharge from the submerged outlet, 30 and 40 feet below the surface, in your opinion will the sewage contemplated to be discharged by the Passaic Valley sewer project rise to the surface from the submerged multiple outlets at or near Robbins Reef?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I believe it will.

Q. And in your opinion, will it or will it not occasion a nuisance to both the nostrils and the eye?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I think it will.

Mr. O'Sullivan: He is your witness.

Cross-examination by Mr. Riker:

Q. What is your business, Mr. Eddy?

A. Consulting Engineer.

Q. Designing sewage disposal plants, part of it?

A. Yes sir.

Q. Your field in the Passaic Valley is a valuable field if you can get in there, for the separate municipalities, is it not?

A. I have never considered it such.

Q. Aren't you concerned in the designing of the plant for Montclair?

A. No sir.

Q. You have been asked to consult on it, have you not?

4084 A. I have made a report on a number of projects in that vicinity.

Q. You are, of course, here, under the employ of the Complainants?

A. I am.

Q. And being paid as an expert for your testimony?

A. Yes sir.

Q. What do you understand is the proposed discharge from the Passaic Valley sewer?

A. The sewage from a population of about 1¾ millions of people or a little under that.

Q. In a crude state?

A. Yes and no, both. That is, crude in the sense that it is not modified by chemical or bacteriological treatment, in the sense usually applied.

Q. Is that as you understand crude sewage?

A. It is crude sewage, although crude or raw sewage is the term sometimes actually applied to the sewage actually flowing in the sewers.

Q. We won't handy words; untreated sewage, you understand it to be untreated sewage?

A. In one sense. It is settled sewage.

Q. Can it be treated in any sense if it is treated at all?

A. Yes.

Q. What sense?

A. In the sense it is not treated with chemicals or bacteriological processes.

Q. Then you mean to say that if it is not treated by these processes it is not treated at all?

A. The word is used loosely, both ways, to include sewage which is treated by chemicals or sewage which is treated by sedimentation, by that process.

Q. Well, when I asked you whether you understand the sewage to be discharged is untreated, what is your answer?

A. It may be or may not. It is treated by sedimentation processes, if you call that treatment, and is not treated by chemicals or bacteriological processes.

Q. I am asking you what you call it, not what I call it; do you call it treated, or do you call it untreated?

A. I should say it was treated by a process of sedimentation.

Q. Now, were you present at the time Mr. Johnson made his dye experiments?

4085 A. I was not.

Q. Have you ever made dye experiments in New York Harbor?

A. I have not.

Q. Do you mean to say that you believe that Mr. Johnson did not observe things that existed?

A. I think that may be the case.

Q. I ask you whether you think it is so?

A. I think it is so.

Q. Or that he is not testifying to what he did really observe?

A. I don't think that.

Q. Are you taking into consideration when you answer the question as to the proposed discharge of the Passaic Valley sewers the stipulation with the United States Government?

A. A part of it at least.

Q. Not the whole of it; are you not taking the whole of it; are you not taking the whole of it into consideration?

A. I am not taking into consideration the statement that refers to its not creating a nuisance.

Q. You mean then by that that is the discharge that is proposed by the Passaic Valley Sewerage Commissioners?

A. I understand that is the discharge which was covered by the agreement.

Q. I ask you whether you wish to be understood as testifying that you do not believe that that is the discharge that is proposed by the Passaic Valley Sewerage Commissioners?

A. Why, I think it is the discharge that is proposed by the Passaic Valley Sewerage Commissioners, but I do not think it can be produced by the works covered by this contract specified.

Q. You were asked on your direct examination at this time whether or not the proposed discharge would result in certain ways which were described to you; you remember that, don't you?

A. No, I do not.

Q. You don't remember that?

A. I do not remember that.

Q. Do you remember being asked as to the proposed discharge?

A. I was asked some questions as to the proposed discharge; yes sir.

Q. And as to its effects in New York Harbor?

A. Yes sir.

Q. Malodorous conditions?

A. I think so.

Q. Unsightly conditions to be produced by the proposed discharge?

A. I don't remember that was covered; I think very likely it was.

4086 Q. Well, now do you mean to say that the discharge as proposed in this stipulation will produce those results in New York Harbor?

A. I don't know what results you mean.

Q. Malodorous results, and results of unpleasant, obnoxious appearances to the eye?

A. I think sewage treated as specified in the contract will produce those conditions.

Q. Will you answer the question directly, Mr. Eddy, and say whether or not in your opinion the effluent discharged as proposed in this stipulation will produce the results which you have testified to?

A. Taking the whole stipulation, I should say not.

Q. Don't you understand that the proposed discharge is that which is guaranteed in this stipulation?

Mr. O'Sullivan: The question is objected to as misleading; the sewage effluent is not gu-ranteed; it is the results that will follow from the discharge of that sewage effluent.

The Commissioner: Note the objection of Counsel for the Complainants.

A. I should answer that question yes.

Q. And do you mean to say that that proposed discharge will produce malodorous conditions and conditions of nuisance as you have testified to?

A. Not if the discharge coincides with the contract, I don't think it will.

Q. Well, do you understand that the contract indicates the proposed discharge?

A. I think it does.

Q. Then, all you mean to say, Mr. Eddy, is that the treatment that is specifically described in this stipulation, in your opinion, will not produce the guaranteed results?

A. That is what I mean, yes sir.

Q. That is all you mean?

A. Yes sir.

Q. And that is what you testified on your direct examination?

A. I may have; I think I did.

Q. And that is a matter of opinion, is it not?

A. It is.

4087 Q. In that you differ from Mr. Johnson?

A. I do, I think. I think I have read his opinion on that.

Q. And you differ from other witnesses whose testimony you have read, for the defence?

A. I think so—yes, for the defence.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Eddy, directing your attention to Complainants' Exhibit No. 135, I ask you as a sanitary engineer if it is possible to produce that effluent with the plant and appliances described in that stipulation?

A. That question appears to apply simply to the effluent and not to the conditions about the outlet. I cannot answer that exactly in that form.

Q. Well, in what condition will the sewage reach the disposal works on the Newark Meadows?

A. I think the suspended matter will be largely disentegrated and broken up into small particles. The sewage during warm weather will be in a putrid condition; there will not be dissolved oxygen in it, it will be offensive, and what may be described as a septic condition.

Q. Treating the sewage that you have now described by passing it through a screen with a 4/10-inch mesh and sedimenting for not more than an hour and a half or giving a detention period not greater than an hour and a half, can you by that mode of treatment produce an effluent that will be in accordance with the stipulated results in Complainants' Exhibit No. 135?

A. I don't think you can.

Mr. O'Sullivan: That is all.

Mr. Riker: No more questions.

Adjourned to June 5th, 1913, at 10:30 A. M.

4088 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, June 5th, 1913—10:30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants.
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

WILLIAM P. MASON, a witness in behalf of the Complainants, recalled in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. Professor Mason, what is your full name?
A. William P. Mason.
Q. Have you testified previously in this suit?
A. I have.
Q. Was your attention specifically directed to pages 3963 to 4121 and pages 4148 to 4162 of the testimony in this case?
A. Yes, sir.
Q. Did you recently undertake any oxygen determinations in relation to the matters that your attention has now been directed to, to verify or to refute those matters?

4089 Mr. Riker: The question is objected to as not being rebuttal.

The Commissioner: Note the objection of Counsel for Defendants.

A. I did.
Q. When?
A. On April 21st and subsequent dates with Professor Phelps, accompanied by Dr. Schwartz and an assistant, I took samples from a point near Robbins Reef, at depths of 5, 10, and 20 feet, the times being, on the 21st of that month, as follows: 11.20, 12.40, 2.30, and 3.55 at Robbins Reef and at Kill van Kull, 1.30 and 3.22. On the 22nd, the times were 10.45, 12.20, 1.40, 3.00 and 4.00 at Robbins Reef; and on the same day, 10.10, 11.30, 1.00, 2.36 and 3.30 at Kill van Kull. Samples were taken then on the 23rd at Robbins Reef; 9.55, 11.00, 11.55, 1.00, 2.10 and 3.18; and at Kill van Kull

10.30, 11.30, 12.30, 1.45 and 2.50. On the 24th they were: 10.25, 11.30, 12.55, 2.03 and 3.12; and at Kill van Kull, 11.00, 12.17, 1.35 and 3.37. On the 25th at Robbins Reef, 9.32, 10.30, 11.25, 12.25, 1.20, 2.30, 3.20; at the Kill van Kull, 10.00, 10.55, 12.00, 12.55, 1.50, and 2.55. On the 26th, at Robbins Reef, 9.30, 10.30, 11.30, 12.23, 1.15 and 2.10; at the Kill van Kull, 10.00, 11.00, 11.55, 12.50 and 1.45.

Q. In taking the samples, did you take the temperature of the water?

A. The temperature was taken at the same time.

Q. And the condition of the tide, was that noted?

A. The condition of the tide as well as the condition of the weather. These samples were analyzed at once for dissolved oxygen, similar samples being taken at the time stated from the Kill van Kull and from Robbins Reef. In all, 224 samples of water were so analyzed.

Q. What were the average results of dissolved oxygen present in the samples during the ebb tide?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The averages for the whole week, giving centimeters 4000 of oxygen per liter, ebb tide, Robbins Reef; 5 feet depth, 5.97; 10 feet depth, 5.94; 20 feet depth 6.01. The Kill van Kull, same data: 5 feet depth, 6.05; 10 feet depth 5.94; 20 feet depth, 6.02.

Q. What do these results show as indicating the difference between the quality of the water of the Kill van Kull and the quality of the water near Robbins Reef Light?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. They indicate the water of the Kill van Kull to be better than the water at Robbins Reef.

Q. In your previous testimony in this case, did you indicate any such difference in the quality of these waters from these two locations?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Q. Yes, basing my opinion at that time upon data secured by the Metropolitan Sewerage Commission.

Q. Did you find in your preliminary investigations and determinations that the dissolved oxygen results from these investigations made by you supports the opinion which you expressed when using the data of the Metropolitan Sewerage Commission?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes. The water of the Kill van Kull was still shown to be better than that of Robbins Reef, but the margin of difference be-

tween the two was smaller, both bodies of water having lost oxygen contents since the time when the Metropolitan Sewerage Commission took the samples.

Q. What, in your opinion, is that smaller margin of difference now due to?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

4091 A. That smaller margin of difference is due to the fact that the water of Newark Bay and consequently the outlet thereof is not as good as it was a few years ago, on account of the large quantity of material having been added to it, in the way of sewage material. The same would apply to any difference noted in the water of New York Bay, between what it is now and what it was at that time.

Q. Have you got the percentages of saturation that were found to exist in the Kill van Kull for 1911 and for Robbins Reef Light region for 1911?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The percentage of saturation for the Kill van Kull was 79 per cent. dissolved oxygen and for the New York Bay 67 per cent. oxygen, both from the Metropolitan Sewerage Commission's data.

Q. Now, applying that ratio to the present average of figures, what do you find in relation to these two bodies of water?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Applying that ratio for the ebb tides, the ratio—using the figures of the Metropolitan Sewerage Commission—should stand 5.97 to 7.04. That is the amount of dissolved oxygen in the Kill van Kull should be 7.04, instead of the 6.06 which it is now, it having got now a smaller quantity of oxygen in solution than it had at that time.

Q. Professor Mason, if such sewage were to receive an inflow of septic sewage, would such addition cause the combined sewage volume to become septic faster or slower than if fresh sewage were allowed to become septic itself by the lapse of time without such inflow?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It would become septic faster for the reason that it would be seeded by an already active growth of decomposition organisms.

4092 Q. What portion of sewage will more readily putrefy, that in which the particles are finely divided and do not quickly subside, or that in which the coarser suspended particles exist?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The more finely divided sewage material will putrefy with greater readiness, and that finely divided material is more common in septic sewage than in fresh.

Q. What difference is there in the oxidizing process when applied to fresh and when applied to septic sewage, in which you have stated the finely divided suspended particles are most plentiful?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. In fresh sewage the process is a biologic one and consequently slower, whereas in septic sewage, the oxidizing process is more largely chemical and direct, and consequently faster.

Q. Which of the two modes of oxidation exhaust the oxygen contents of a body of water most rapidly?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The second one, that is the septic sewage, would more rapidly exhaust the oxidizing reserve of the water into which it flowed, as compared with the same quantity of fresh sewage.

Q. Does septic sewage give off malodorous gases?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes.

Mr. O'Sullivan: He is your witness, Mr. Riker.

4093 Cross-examination by Mr. Riker:

Q. Your attention has been directed to certain testimony contained in the transcripts which you have seen; what part of that testimony do you think is affected in any way by the observations that you made in the Kill van Kull and at Robbins Reef?

A. My attention was directed in reading that testimony over, to a statement made that sewage contained a considerable amount of oxygen and consequently had a refreshing influence upon the water into which it was emptied.

Q. You understand that that is this statement as Mr. Johnson made it?

A. Mr. Johnson made that statement as I understand it.

Q. Without limitation or description or definition of any kind?

A. Yes, there was some limitation. He at least led me to believe that he was dumping that sewage into water which was already pretty heavily polluted.

Q. More or less than the sewage that was being dumped?

A. I beg pardon?

Q. Was it more or less deteriorated by pollution than the sewage discharge itself, as you understand his statement?

A. I do not remember the relation between the two bodies, but I think his intention was to convey the impression that the liquid into which he was dumping it was more polluted than the sewage he was dumping in.

Q. And you disagree with that if that is the testimony?

A. No, I don't disagree with that particularly.

Q. Well, what other part of Mr. Johnson's testimony do you think is affected in any way by the experiments which were conducted and the determinations of oxygen at the Kill van Kull and at Robbins Reef to which you testified?

A. The point which I note now is a statement of his that the large particles of sewage will putrefy more readily than the smaller ones. I cannot agree with that.

Q. No; what I asked you was what relation do the experiments that were had on oxygen determinations in the Kill van Kull
4094 and at Robbins Reef, in your opinion, bear to any of his testimony?

A. I do not think it bears any relation to that, do you; except that he referred to the dissolved oxygen in the sewage and to the quantity of dissolved oxygen in the liquid into which the sewage was dumped.

Q. I know; but I am directing your attention now particularly to your determinations of oxygen at these two points. I want to find out what testimony that was given by Mr. Johnson you think that has any relation to?

A. Well, merely this: his statements were made with reference to the effect that sewage would have upon a water into which such sewage stream was allowed to flow.

Q. You don't understand there is any such sewage stream allowed to flow into the Kill van Kull or Robbins Reef now, do you?

A. No, not straight sewage; that is so.

Q. Well, have you any doubt that the waters of the Kill van Kull are actually polluted with sewage?

A. Oh, surely.

Q. What?

A. Surely they are.

Q. And have you any question that that pollution to a large extent comes from the Passaic River?

A. No doubt of it.

Q. And that the more greatly deteriorated condition of the waters at Robbins Reef is contributed to by the conditions of the waters of the Kill van Kull; you have no doubt of that, have you?

A. Well, the Kill van Kull water is better than that at Robbins Reef.

Q. I understand that, but have you any doubt that the conditions of the Kill van Kull water are nevertheless contributed to by the deterioration of the conditions of the Robbins Reef water—that the conditions of the Robbins Reef water was contributed to by the condition of the Kill van Kull water?

A. No, I cannot admit that, because it is better.

Q. Do you mean to say that if the Kill van Kull water was not polluted at all, that it would not have a beneficial effect upon the conditions of Robbins Reef?

A. Oh, surely it would.

4095 Q. Well, when you deteriorate the waters near the Kill van Kull, wouldn't that have an effect on the waters at Robbins Reef?

A. It would lessen the quantity of improvement.

Q. Do you think, therefore, the conditions of the Kill van Kull water contributes to the conditions of the water at Robbins Reef?

A. In that it lessens the amount the amount of improvement; it surely does.

Q. So that if you remove out of the waters of the Kill van Kull, the pollution due to the Passaic River, you would naturally improve the conditions at Robbins Reef?

A. Whatever you do in order to improve the Kill van Kull would surely improve conditions at Robbins Reef.

Q. I am asking you a specific question; if you remove the sewage of the Passaic Valley from the Passaic River and therefore from the Kill van Kull, don't you think the waters at Robbins Reef would be improved?

A. You haven't stated what you do to improve it.

Q. You are not going to put it into Robbins Reef water; you are simply going to remove it?

A. That is true.

Q. Well, now, Professor Mason, with respect to the abstraction of the oxygen in water, do you think that that abstraction is more nearly produced or caused by deposits of organic matter on the floor of the body of water, or when it is held in suspension and removed from time to time by the ebbs of the tides?

A. The quantities being the same? If I understand you, given a certain amount of septic sewage, allowed to deposit, or allowed to stay in suspension, under which circumstances would that give an amount of pollution to reduce the dissolved oxygen?

Q. Recognizing the fact that the matter in suspension is being carried out by the ebb tide and dispersed in the course of six tides. I will add that to the question.

A. There is no question whatever but that the same amount of material in suspension would be a greater strain upon the oxygen and use it up faster than that same quantity in deposits on the bottom or the floor of the harbor, because it is brought into contact with the oxygen and is more putrescible.

4996 Q. Well, taking the conditions in the harbor of New York for example, do you understand that the deterioration in oxygen is more largely due to the suspended matter or the matter that has been deposited in the shape of muds on the floor of the bay or harbor?

A. Without further information I should say that it was used up more by the septic material in suspension.

Q. If the witnesses for the Complainants have testified to the contrary, you don't agree with them?

A. Not unless they give me more information than I have from your questions.

Q. Well, what character of sewage material is more likely to be deposited on the floor of New York Bay, the fine matter or the larger matter?

A. Oh, the larger matter.

Q. Isn't that what you understand Mr. Johnson testified to?

A. I don't recall that; that is not to what I referred a moment ago when I spoke of the testimony.

Q. Well, if he is testifying that the larger matter being more subject to deposition on the floor of the harbor or the bay was more provocative of the condition of lessening oxygen than the finer matter which was held in suspension, and would be carried out on the tides, do you disagree with him?

A. I don't quite understand that.

Q. What I mean is, whether you think the heavy matter which is deposited on the floor of the harbor will reduce the oxygen more than the finer matter which is in suspension and which is carried out on the succeeding tides?

A. If the finer septic matter is carried through the waters, it would be; that it would come into contact with the oxygen more quickly and that would reduce the oxygen more readily.

Q. You disagree with him on that basis, do you?

A. If I understand the question, I do; yes.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Professor Mason have you studied the oxygen tabula-
4097 lations and determinations made for the year 1909 and the year 1911 by the Metropolitan Sewerage Commission?

A. I am not sure of the date. I have studied practically all they have got. I cannot swear to the date.

Q. Do you recall whether or not, Professor Mason, you studied two sets of tabulated dissolved oxygen determinations for any two years prior to your first testifying in this suit?

A. Yes, I studied all the oxygen then.

Q. Do you recall one set was for the year 1909 and the other set for the year 1911?

A. My impression is those are the dates.

Q. From your study of the tabulations for the year 1909 and the year 1911, and the determinations made by yourself in the same regions of Robbins Reef and the Kill van Kull, do you find a steady decline or not, in the oxygen contents?

Mr. Riker: I object to that question on the ground that it is not redirect examination.

The Commissioner: Note the objection of Counsel for the Defendants.

A. I cannot answer that without reference to the figures and I do not carry them in my head. That is, at the Kill van Kull, there has been a decline. I cannot give you the figures.

Q. I was asking you for the fact, Professor Mason, not the figures?

A. I can answer it as a fact for the Kill van Kull. I would have to refer to the record for the rest of the answer.

Q. How about Robbins Reef?

A. That is the part I will have to have the figures for before I answer.

Q. Are fine suspended septic particles oscillating on several sides in a body of water capable of exhausting that body of water of its oxygen contents more rapidly than heavier particles that have been sedimented and deposited on the bottom of that body of water?

A. Yes.

Mr. O'Sullivan: That is all.

Mr. Riker: That is all. No more questions.

4098 CHARLES E. NORTH, a witness in behalf of the Complainants, recalled in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Doctor?

A. Charles E. North.

Q. You testified a couple of days ago in this suit?

A. Yes, sir.

Q. On the subject of bacteriology?

A. Yes, sir.

Q. Have you made any specialty within your profession, and if so, state what it is, Doctor, and what your experiences were in that specialty?

A. I have made a specialty of consulting sanitary work and public health work. I am a practicing sanitarian.

Q. Where have you made any investigations, what experience have you had?

A. I was trained in bacteriology in Wesleyan University at Middletown, Connecticut, where I took the degree of A. B. and also specialized in chemistry under Atwater at the same institution. I was trained in medicine and took the degree of M. D. at Columbia University, after which I took a Post Graduate course at the same institution in bacteriology. I was director of the Department of Bacteriology in the Lederle Laboratories for 3 years, during which period I had charge of all the important sanitary investigations which were conducted by those laboratories. These included chemical and bacteriological examinations in the laboratories and also extensive inspections connected with epidemics and sanitary work outside of the laboratories. For two years I was employed by Jersey City as bacteriologist in the litigation which that City conducted against the Jersey City Water Supply Company, and during that period had charge of all of the bacteriological work, connected with the investigations of the Jersey City Water Supply. For five years, I have been practising privately as a consulting sanitarian and during that period have maintained laboratories for chemical and bacteriological work of my own, and have had charge of the investigation of a variety of sanitary problems including several large epidemics of disease. These epidemics have included scarlet fever, dip-the-
4099 ria, typhoid fever, septic sore throat and some other minor outbreaks. In this connection it has been necessary for me to pay particular attention to vital statistics and the work carried out by public health officials, in large and small cities. As a conse-

quence, I have made a special study of the broader aspects of public health problems and have published a number of papers on public health questions. I am frequently consulted by public health authorities in large and small cities on special questions of public health.

Q. Dr. North, has your attention been specifically directed and have you read the testimony given on pages 4107 to 4112, both inclusive, given by Mr. George A. Johnson, on the production of indol, skatol, phenol, cadaverin, mercaptan, phosphein, cresenol and the other putrefactive products testified to on the pages named?

A. I have, yes, sir.

Q. I direct your attention specifically to the last question on page 4111 of the record: "Q. Do you regard indol, skatol, cadaverin, mercaptan and these other compounds that we were considering as more or less repulsive than sulphuretted hydrogen? A. I expect it is all a matter of taste or smell. Q. In your particular case, which do you regard as the most repulsive? A. Well, I do not particularly like any of them, but probably indol is the most offensive" etc. Is indol the most offensive of the gases and putrefactive products that I have mentioned previously in the question?

A. No, sir, it is not.

Q. Which do you consider the most repulsive of these odor nuisances?

Mr. Riker: The question is objected to on the ground that it is not rebuttal, the testimony of the defendants' witness, being that so far as he was concerned he recognized one of these as more offensive than the other, and what this witness may recognize is not rebuttal of what the testimony of the defense was.

The Commissioner: Note the objection of Counsel for the Defendants.

A. I consider that hydrogen sulphide and mercaptan are far more offensive than indol and I believe I am supported in that by other authorities.

Q. I direct your attention to a question and answer appear-
4100 ing on page 4112 of the record: "Q. Is there any provision made in the sewage disposal works of the Passaic Valley Sewerage Commissioners for the removal of these substances from the sewage to be treated at or near the Newark Meadows? A. We gave some consideration to the feasibility of removing these odors should they be present, from the sewage before it is discharged into the Bay. We were unable to find any feasible method for so doing, that would come within reasonable cost. As a matter of fact, so far as I know, this is not done in connection with any sewage disposal project in the world." Can sewage be so treated as to remove these odors?

A. It can.

Q. Mr. George A. Johnson has testified that the sewage effluents proposed to be discharged by the Passaic Valley Sewerage Commissioners will occasion no injury to the public health and will create no private or public nuisance in accordance with the stipulation in

Complainants' Exhibit No. 135. In your opinion will the sewage effluent proposed to be discharged by the Passaic Valley Sewerage Commissioners occasion public or private nuisance, and will such nuisance be injurious to the public health?

A. In my opinion the discharge of the sewage from the Passaic Valley sewer will occasion a public and private nuisance and will cause odors which will be injurious to the public health.

Q. What injury to health do odor nuisances occasion, Dr. North?

Mr. Riker: Objected to as not being rebuttal of any evidence of the defense.

The Commissioner: Note the objection of Counsel for the defendants.

A. The effect of odors upon health depends upon two things: first, the susceptibility of the persons affected; and, second, the character of the odors themselves.

Q. Taking the character of the odors themselves, how do these putrefactive odors affect health injuriously?

4101 Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. The offensiveness of an odor depends upon its effect on the nerves of smell and upon its intensity and its character and the duration of time over which it reaches individuals.

Q. Is that injury to health from nuisance odors a recognized one by Boards of Health?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. It is universally recognized by sanitary authorities that odors are nuisances and legislation has bee- directed against odors by all constituted health authorities. I might illustrate the character of these prohibitions, by citing from a few sections of the Sanitary Code of New York City. Section 10 of the Sanitary Code of New York states: "That it is hereby declared to be the duty of every owner * * * lessee * * * of any place * * * to keep place and preserve the same and the sewage, drainage and ventilation thereof in such condition and to conduct the same in such manner that it shall not be a nuisance or be dangerous or prejudicial to life or health."

Section 20 states: " * * * no offensive smell or gas from or through any outlet or sewer or through any such privy or water closet shall be allowed * * * to pass into such house or any part thereof."

Section 33 states: "Every water closet * * * must be separately and effectively trapped."

Section 36 states: "Water and soil pipes in every lodging house or dwelling shall be ventilated."

Section 17 states: "No owner * * * shall lease or let or hire out any building * * * which is impregnated or penetrated by any offensive gas or smell or exhalation prejudicial to health."

Section 38 states: "No person * * * shall * * *
4102 allow any sewage, drainage, factory refuse or any foul or offensive liquid to flow, leak, escape, or be emptied into any river, stream, canal, etc., excepting under low water mark and in such manner and under such conditions that no nuisance can or shall be caused thereby."

Section 88 says: "No person shall permit or have any offensive water or other liquid or substance on his premises * * * no establishment * * * for carrying on any offensive or noisome business shall hereafter be opened * * * in the city of New York. * * * Such establishment now existing shall be * * * so conducted * * * as not to be offensive or prejudicial to health or life."

Section 99 states: "No ground or material filled with offensive matter * * * or that will emit or allow to raise through or from the same any offensive smell or deleterious exhalation shall (adjacent to or within the built up portion of said city) be opened."

These extracts show that odors are recognized as nuisances by the Department of Health.

Mr. Riker: Counsel for the Defendants moves to strike out all this testimony in regard to the Code of Health of New York City, as not being responsive to any questions and not being anticipated on the ground that they are not properly proved, not material and not rebuttal.

The Commissioner: Note the motion of Counsel for the Defendants to strike out.

Q. Are the various sections that you have just alluded to from the New York City Department of Health exceptional, or are they generally recognized by Health Boards throughout the United States?

Mr. Riker: The question is objected to as not rebuttal, as immaterial and improper.

The Commissioner: Note the objection of Counsel for the Defendants.

A. They are generally recognized by sanitary authorities, throughout the United States.

4103 Q. Are they embodied in their sanitary codes as prohibitions?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. They are embodied in their sanitary codes.

Q. Have any great sanitarians investigated the gaseous products of decomposition arising from sewers and their injury to health?

Mr. Riker: The question is objected to on the ground that it is not rebuttal and is immaterial and irrelevant.

The Commissioner: Note the objection of Counsel for the Defendants.

A. Many sanitarians have investigated gaseous products of sewage and their relation to public health. Some of these I have collected.

Kirchner & Lindley in 1905 published a paper before German Society of Public Health, in which they state: "The gaseous products of decomposition arising in sewers and house drains may be harmful indirectly, if not directly, to those exposed to them for a considerable time. They may produce nausea and may lower the general tone of the body, including its resistance against disease." Godfrey, in a book entitled "The Health of the City" published in 1910, said: "It is entirely possible that odors of sewer gas interfering with appetite and digestion might weaken the condition. * * * A research conducted by Dr. Allessi of the University of Rome, indicated that animal life when exposed to the effect of gases produced by decomposition in sewage lost its power of resistance to certain specific germ diseases. * * * Roechling, in book entitled "Sewer Gas and its influence on Health" believes that the action of sewer gas may predispose the individual to attacks of disease.

R. C. McFie in a book entitled "Air & Health" published in 1909, states: "To bad air we attribute much of the anemia, the pallor and the neurasthenia, the general ill health of the slum dweller and factory worker and most persons engaged in sedentary indoor
4104 occupations * * * (Page 133). Any one who compares his power of mental work in a pure and in a carbonic-acid-laden atmosphere, even if the latter be dry and cool, will find in the latter a considerable diminution, showing that at least nerve metabolism is affected. Nature has taken such particular pains to supply the nervous system with particularly pure, well-oxidized blood, that it is probable a very small oxidative difference may have considerable consequences. (Page 134.) It may be contended that the human constitution becomes in time accustomed to vitiated air, and that much of the ill health ascribed to bad air is really due to other circumstances, such as poor feeding and depressing surroundings, but the difference in health between country poor and city poor, and the improvement in health which always follows removal from impure to pure air is sufficient answer to such a contention. * * * An open window may work wonders; and the improvement in appetite, nerve vigor, blood quality and muscular tone which follows open air treatment even in the rich and well fed, shows the paramount importance of fresh air. Can it be doubted when even a whif of air may revive a fainting patient?" Page 23: "The air of towns, even in clean well ventilated streets has a slightly larger percentage of carbon dioxide than country air. Thus Boussingault and Levy found .0319 per cent. of carbon dioxide in Paris air, and only .0299 per cent. in Andilly, a small village 12 miles away."

Q. What is the composition of normal air?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. The composition of normal air: Oxygen 20.94; Carbon dioxide 0.03; Nitrogen 78.09; Argon 0.94. There are also traces of Helium, Krypton, Neon, Xenon, Hydrogen peroxide, Ammonia, and in addition water vapor in various amounts, nitric acid, nitrus acid, radioactive substances and dust. In an adult man about 500 c. c. of air is

inspired and expired at each breath at the rate of 15 to 16
4105 times a minute. The normal lungs hold a total volume of
about 3,500 c. c. The total of 3,500 c. c. in the chest is made
up as follows.

Tidal air	500 c. c.
Supplemental or reserve air	1,500 c. c.
Residual	1,500 c. c.

By force it is possible to add another 1,500 c. c. in inspiration, making a total of 5,000 c. c.

Gaseous changes in air and blood in respiration:

	Oxygen.	Nitrogen.	Carbon dioxide
Inspired air	21	78	.03
Expired air	16	79	4.3
Blood reaching lungs	8 to 12	1.2	46
Blood after exposure to air in lung	20	1.2	40

Q. Has any experimental work been done to determine the percentage of carbon dioxide in city air, and if so, state such facts as you have in relation thereto and the effect of odors in conjunction therewith?

Mr. Riker: The question is objected to for the same reason as to the last question.

The Commissioner: Note the objection of Counsel for the Defendants.

A. In the same publication on "Air and Health" above referred to th statement is made regarding experiment work that Haldane & Osborn found a percentage of carbon dioxide in tailoring workshops from .320 to .532 * * * in textile factories from .032 to .470. * * * Dr. Scott Tebb found .038 in the open streets and .116 in the tube railway carriages. On the average during complete rest a man discharges about .6 of a foot of carbon dioxide per hour and a woman about .4 of a cubic foot * * * Page 123. After the battle of Austerlitz 300 Austrian soldiers were shut in a small
prison and 260 were killed by the impure air. In the tragedy
4106 known as the Black Hole of Calcutta, January 18th, 1756,
146 adults were shut in a room 18 feet square, with only two small windows to ventilate it. They were shut in at 8 P. M., within an hour some were dead; when the door was opened at 6.20 the next morning, only 23 were left alive * * * Page 129: Air containing merely the carbon dioxide and moisture usually contained in vitiated air, will not produce the effect of vitiated air, and vitiated air must therefore contain an additional constituent. This additional constituent, though undetected by chemists, is probably detected by the nose, for it is well known that air is oppressive and harmful not so much in proportion to the amount of carbon dioxide and moisture it contains, as in proportion to its smelliness. The relation between organic effluvia and the healthful performance of physiological

functions is so close that a bad smell may cause nausea or faintness. The very fact that the nose is so sensitive to such odors would seem to suggest their harmfulness * * * Parkes and Kenwood suggest that the action of odoriferous volatile substances on the olfactory nerves may ultimately induce through the central nervous system alterations in respiration, circulation and nutrition, which are inconsistent with the maintenance of good health * * * Always during City fogs sickness increases and the death rate rises. Increase in the City of London for one week ending January 2nd, 1892, after a fortnight of dense fog the deaths exceeded by 1,484 the average number. Increase took place in the following diseases: Measles 114 per cent; Whooping Cough 173; Phthisis 42; Old age 36; Apoplexy 58; Circulatory diseases 106; Bronchitis 170; Pneumonia 111; other respiratory diseases 135 * * * No doubt much chronic ill health anemia, neurasthenia, dyspepsia, etc., may be produced by such polluted air * * * We have talked so far of the ordinary smoke and ordinary smoke fog * * * The Public Health Act of 1891 enacts "For the purposes of this Act, any fire place or furnace which does not so far as practicable consume the smoke arising from the combustible used therein * * * or * * * which emits black smoke in such quantities as to be a nuisance, shall
4107 be deemed a nuisance and liable to be dealt with summarily in the manner provided by this Act."

The Act of 1863 enacted that smoke must not contain more than 5 per cent. of hydrochloric acid * * * Law, therefore, has done something to prevent the pollution of the atmosphere.

Q. Dr. North, do the odors themselves emanating from putrefactive sewage affect health?

Mr. Riker: The same objection.

The Commissioner: Note the objection of Counsel for the Defendants.

A. They do, and I find that my observations are fully supported by those of many eminent sanitarians, such as Harrington in "Practical Hygiene" states: "The chief importance of sewer gas lies not in its power to produce disease but in its capacity for being a vehicle for odors which make the air disagreeable, but not necessarily dangerous to health, except that appetite and digestion, and hence general nutrition may be interfered with" * * * It is asserted commonly that the inhalation of small amounts of this air will produce headache, anemia, loss of appetite. Page 244: Disagreeable smells do not act directly as the cause of specific disease, but appear to have an influence on the appetite and hence on the general well being of persons not accustomed to them. * * * It seems probable also that there is much to learn concerning the real effects of disagreeable smells and that they may be more extensive than we now commonly believe." Egbert in "Hygiene and Sanitation" states: Either soil-air or sewer-gas may possibly at times carry the germs of infectious diseases. Their influence, however, is usually insidious, owing to dilution with the house-air; and the most common sym-toms will probably be pallor, languor, frequent headache

and loss of appetite. Notter & Firth, page 159: "There is undoubtedly a poisonous agency at work when sewer gas is inhaled, which though it may not directly act, yet so prepares the soil that the system is unable to resist the invading organism when it comes."

Valery Havard, "Manual on Military Hygiene" 1909, page
4108 331: "Plumbing fixtures properly trapped completely exclude sewer air, so that if foul smells are noticed they are almost always due to decomposition of excreta or other organic matter within the fixtures, pipes or traps. Such smells may produce headache and affect the appetite and digestion."

Whitelegge and Newman "Hygiene and Public Health," 1910, page 258: "Air contaminated by sewage emanations may, however, be a cause of diarrhœa and other gastro-intestinal disturbances, and of certain forms of sore throat. Anæmia, depression and general ill health may result from protracted exposure to such an atmosphere."

Bergey, in "Principle of Hygiene," 1904, page 51, states: "When a portion of a sewer or the drainage-pipes of a house become obstructed so that there is no longer a free circulation of air in the obstructed portion, then there is an accumulation of putrefactive gases, such as carbon dioxide, hydrogen sulphid, marsh gas, etc., and these gases are highly injurious when inhaled in considerable quantities, or in smaller amounts for a considerable time." Page 56, "The odor of animal organic matter when present in the air, even in small amounts, is very offensive and readily detectable." Page 60: "Hydrogen Sulphid. This gas acts as a narcotic poison; one volume per 1,000 volumes of air being fatal to dogs. The chronic effects produced by inhalation of small quantities are depression, digestive disturbances, and anemia, with narcotic or convulsive symptoms in more acute and severe cases." Page 61:

"Slighter vitiation of the air when continued for some time cause anemia, weakness and general depression of the vital forces, nutrition being gravely interfered with. * * * It is a matter of fact that headache, malaise, want of appetite and energy, are caused by habitual breathing of impure air."

William H. Howell, "A Text-Book of Physiology," 1907, page 284: "Even in ourselves the actual amount of olfactory material which suffices to give a distinct sensation is often beyond our means of determination, except by the aid of calculation. It is recognized in chemical work for instance, that traces of known sub-
4109 stances too small to give the ordinary chemical actions may be detected easily by the sense of smell. By taking known amounts of odoriferous substances and diluting them to known extents, it is possible to express in weights the *minimal* amount of each substance that can cause a sensation. By this method such figures as the following are obtained: Camphor is perceived in a dilution of 1 part to 400,000; musk 1 part to 8,000,000; vanillin 1 part to 10,000; while according to the experiments of Fischer and Penzoldt, mercaptan may be detected in a dilution of $\frac{1}{23,000,000}$ of a $\frac{1}{460,000,000}$ of a mil-igram in 50 c. c. of air."

Osler, "The Principles and Practice of Medicine," 1899 Page 343: "Cases which follow exposure to foul odors or sewer gas. That a febrile paroxysm may follow a prolonged exposure to noxious odors has long been recognized. The cases which have been described under this heading are of two kinds: an acute severe form with nausea, vomiting, colic and fever, followed perhaps by a condition of collapse or coma; secondly, a form of low fever, with or without chills. A good deal of doubt still exists in the minds of the profession about these cases of so-called sewer gas poisoning. * * * There are instances in which persons have been taken ill with vomiting and slight fever after exposure to the odor of a very offensive post-mortem. The idea is firmly implanted in the minds of the laity that very powerful odors from decomposing matters may produce sickness. Page 451: In so many instances defective drainage has been found associated with outbreaks of follicular tonsillitis that sewer gas is regarded as a common exciting cause."

C. A. Herter, M. D., "The common Bacterial Infections of the Digestive Tract." 1907, page 226: Sulphur Compounds. The sulphur compounds resulting from putrefactive decomposition in the intestine, have received little attention from the standpoint of their pharmacological action. It is therefore difficult to form a just estimate of their importance for intestinal intoxications. It was claimed by Nencke that methyl mercaptan is one of the gases formed
4110 in the intestine during putrefaction. * * * It appears to me, therefore, not clear that the methyl mercaptan found by Nencke was formed during putrefaction outside the body. Page 241. Indol. It has long been known the Indol is a product of putrefactive decomposition of proteids. * * * The observation has been repeatedly made by clinicians that persons in whom a very strong indican reaction can be obtained * * * invariably suffer from nervous or dyspeptic disordors, and many careful physicians have believed in some casual connection between the observation of Indol from the intestine and the development of functional nervous or nutritional derangements."

Rideal in book entitled "Sewage," 1906, page 97, states: "The amount of oxygen required to render inoffensive the substances occurring in sewage depends on the species of the bacteria which are acting, as they determine whether the result should be complete burning to CO_2, H_2O, and N, or a partial decomposition to equally harmless compounds like NH_3 and CH_4. There are a number of intermediate products; thus Streptococcus longus liquefies fibrin to ammonia, methylamine, trimethylamine, tryosine, leucine, fatty acids, succinic acid, collidine and peptones. Elastine with anaerobic organisms, evolves CO_2, H, CH_4, and N, whilst the sulphur remains in solution as mercaptan, and is not evolved as H_2S. Page 173: "It is a mistake to suppose that the odorous ingredients in sewage are all basic like ammonia, or readily combine with chemical reagents. * * * In distilling sewages or contaminated waters for ammonia and albuminoid, the distillate will be found to have a peculiar nauseous, somewhat aromatic odor, which is so constant that in waters it points strongly to sewage admixture. * * *

The compound collects as a greasy white scum on the top of the distillate. * * * It is very difficult to separate. In small quantities it floats like a grease on the surface of the water: from its odor and general occurrence though in minute amounts, it would seem to be an important cause of the residual sewage odor when ammonia, etc., have been removed. * * * Ethereal salts,
4111 like mercaptan, may also be mentioned among the many substances which may render chemical deodorization inefficient." Dunbar and Calvert, "Principles of Sewage Treatment" 198, Page 40: "Sewage Nuisances.—The most manifest nuisances which arise from present methods of sewage disposal are * * * the formation of sludge deposits * * * the turbidity and color of the water * * * the putrefactive changes which occur and give rise to all bad smells chiefly of sulphuretted hydrogen and also in the putrefying sludge which sometimes rises to the surface of the streams. Such nuisances have attained dimensions so serious in some districts that for long distances it is impossible to dwell on the banks or in the neighborhood of the rivers."

Q. In your opinion, Dr. North, do odors constitute a nuisance?

Mr. Riker: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

A. They undoubtedly do. The creation of an odor is recognized by Public Health authorities as one form of nuisance against which their activities must be directed for the protection of public health. The odors created by putrefaction of sewage are among the most prominent of these. The creation of an odor by the putrefaction of sewage in New York Harbor and the transmission through the air of the Harbor to the inhabitants of New York City would be a menace to the health of said inhabitants. The effect of an odor depends upon two things—(*a*) the susceptibility of the persons affected, and (*b*) the character of the odor, or odors.

Q. Dr. North, in answering a question of mine earlier in your testimony, you stated that the effect of an odor nuisance depended upon two things, susceptibility of persons affected and the character of odors themselves. I now ask you what you mean by the "Susceptibility of persons affected," and ask you to give in detail the factors that either create or accentuate such susceptibility as is embraced in your expressed opinion?

Mr. Riker: The same objection.

The Commissioner: Note the objection of Counsel for Defendants.

4112 A. It can be shown that the inhabitants of New York City are peculiarly susceptible to the effect of odors. The character of life in New York City, the habits of the people and the nature of the business transacted in New York City exert influences upon the public health which are not experienced to the same degree in small communities. The most important of these influences may be characterized as under the title of "The pressure

of Modern Business." This pressure is exerted upon the individuals inhabiting the City in a number of direct ways. From the transactions of the New York Post Office published in the year 1893 to 1910, inclusive, the figures are given showing the quantity of first class mail matter received in incoming mails and originating in New York City. These together show the total number of letters handled by the Post Office in New York City each day. I submit in Table No. 1, a tabulation of these figures for the years 1893 to 1910, inclusive, which show that the total daily letters handled have increased from 1,051,000 to 2,663,000. This increase is illustrated graphically in Chart No. 1, which I also submit.

Transactions of the New York City Post Office Prepared for the Annual Report of the Chamber of Commerce by Direction of Hon. E. M. Morgan, Postmaster.

Average Quantities of Mail Disposed of in One Day for the Following Years.

	Originating in New York (outgoing.)	Received in mails (incoming.)	Total daily letters.
1893	901,363	150,140	1,051,503
1895	944,458	138,661	1,083,119
1897	1,044,656	157,825	1,202,481
1898	1,144,669	149,892	1,294,561
1900	1,372,006	208,074	1,580,080
1901	1,561,033	252,169	1,813,202
1902	1,657,160	273,582	1,930,742
1903	1,716,390	284,121	2,000,511
1905	2,059,455	327,874	2,387,329
4113			
1906	2,034,973	356,655	2,391,628
1907	2,168,738	397,975	2,566,713
1908	1,997,533	376,789	2,374,322
1909	2,201,916	383,739	2,585,655
1910	2,251,148	412,009	2,663,157

Q. Dr. North, who prepared the Chart No. 1, which you now produce?

A. I did.

Mr. O'Sullivan: I offer the Chart marked No. 1, perpared by this witness in evidence and ask that it be marked Complainants' Exhibit No. 207.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 207.

The Witness (continuing): Another important factor in busi-

ness pressure is the increase in passenger railroad traffic. In the Report published by the Public Service Commissioner of the State of New York, January 10th, 1912, is contained statistics of the city railway traffic of the City of New York from the year 1860 to the year 1911 inclusive. Among other figures it is shown that all of the street railways of Greater New York carried in the year 1860 a total of 50,830,173 passengers, while in 1911 the railways carried 1,551,144,963 passengers. The relation of the passengers carried to the population is shown in the tabulation which I submit under the title of "Table No. 2, Growth of City Railway Traffic in New York City" showing that the rides per capita were 43 in the year 1860, while in 1911 there were 315 rides per capita. This increase in railway passenger traffic is graphically illustrated in Chart No. 2 which is herewith submitted.

4114 *Growth of City Railway Traffic in New York City.*

Total Street Railways.

Year.	Per capita.
1860	43
1870	103
1880	152
1890	218
1900	246
1901	248
1902	256
1903	265
1904	274
1905	283
1906	301
1907	305
1908	303
1909	301
1910	312
1911	315

Q. Dr. North, who prepared the Chart No. 2, which you now produce?

A. I did.

Mr. O'Sullivan: I offer the chart marked No. 2 prepared by this witness in evidence, and ask that it be marked Complainants' Exhibit No. 208.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 208.

The Witness (continuing): There is no one feature of modern business life which makes more constant demands upon the
4115 attention and therefore upon the nervous system than the telephone. The growth of the telephone business is one of the wonders of modern business life. In the United States Census

report of 1907 there appears figures showing the growth of the telephones in service in the Boroughs of Manhattan and Bronx, City of New York. From these it appears that in the year 1881 there were 2,973 telephones in these Boroughs, while in 1907 there were 240,590. From the Report of the American Telephone & Telegraph Company of May 1st, 1912, figures showing the growth of telephones in the United States are given for the year ending 1910. These show that in 1895 there were 2,402,543 telephones in the United States, while in 1910 there were 22,284,010. I have estimated from these figures and other statistics in this report that the number of telephones actually in use in New York City in the year 1910 was 350,000. In Table No. 3 which I submit is a tabulation of the figures from the United States Census Report and also a statement of the population of the Boroughs of Manhattan and Bronx: I also submit Chart No. 3 which illustrates graphically the growth of telephone business in New York City. The number of telephone calls per day for each instrument increases with the number of instruments installed. For instance, the Report of the United States Census Bureau for 1907 states that in New York City, there were in the year 1902 4-½ telephone calls per station per day, while five years later, in the year 1907, there were five calls per station per day.

4116 *Number of Telephones in Service, New York City.*

(Manhattan & Bronx.)

Date.	Telephones.		Population.
1881	2,973	(1880)	1,206,299
1889	7,454	(1890)	1,515,301
1894	11,218		
1898	23,046		
1899	28,423		
1900	40,437		2,050,600
1901	54,650		
1902	72,182		
1903	96,359		
1904	121,935		
1905	144,353		
1907	240,590		
1910	350,000	(estimated)	2,762,522

Q. Dr. North, who prepared the Chart No. 3, which you now produce?

A. I did.

Mr. O'Sullivan: I offer the Chart marked No. 3 prepared by this witness, in evidence and ask that it be marked Complainants' Exhibit No. 209.

Mr. Riker: Same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 209.

The Witness (continuing): The statistics of the Telegraph Companies are exceedingly meagre and the Census reports and Reference Books contain little information, for the reason that the Telegraph Companies have declined to furnish same. Statistical information contained in the Scientific American Reference Book
4117 for 1913, shows that the telegraph traffic increased from the year 1900 to 1910 to the extent of at least 35%. The Report of the American Telephone and Telegraph Company shows that the number of telegrams were equal to about 2 per cent. of the number of telephone messages in the year 1900, and about one per cent. of the number in the year 1910. In the United States, it is stated in this Reference Book, that for each 1,000 population in 1909, there were, 96,090 pieces of first class mail matter, 1,076 telegrams and 137,882 telephone conversations as against 90,062 pieces of first class mail, 1,039 telegrams, and 134,335 telephone conversations in the year 1908. From the figures given in the report of the American Telephone & Telegraph Company, I have estimated that in New York City there were in the year 1890, 20,000 telegrams, in 1900, 29,719 and in 1910, 33,289. The demands on the telegraph service, have, of course, been greatly decreased by the installation of the telephone. That the increase in telegraph messages as well as in other factors has been much greater in the United States than in Europe is illustrated in Table No. 4, which I submit herewith.

Percentages of Messages in the United States.

Traffic per 1,000 Inhabitants.

Mail, 40.9%.
Telegraph 0.4.
Telephones, 58.7.

	Europe.			United States.		
	Teleph.	Telegr.	Mail.	Teleph.	Telegr.	Mail.
1908.....	10,585	769	34,766	134,335	1,039	90,062
1909.....	11,400	798	35,533	137,882	1,076	96,090
Increase.....	7.7%	3.7%	2.2%	2.6%	3.5%	6.7%

Scientific American Reference Book 1913.

The growth of activity in the Post Office, Railroad transportation, Telephone and Telegraph must be measured against the growth in population to get a true index of the absolute increase in business pressure upon the inhabitants of New York City. I have, therefore, drawn up a table showing the population, the number of letters daily handled, the daily number of passengers carried by the New
4118 York City railroad lines, the number of daily telephone calls, and the number of daily telegrams sent and received for the years 1890, 1900 and 1910. These figures appear in Table No. 5, which I submit herewith. The growth of population and of these business activities is illustrated in Chart No. 5, which accompanies this Table.

Growth of Population and Business, New York City.

			Daily communications.	
Population.	Letters.	Railroad passengers.	Telephone calls, U. S.	Telegraphs.
1890..... 2,420,817	1,000,000	1,559,313	232,800	20,000
1900..... 3,225,324	1,580,080	2,321,515	1,164,000	27,719
1910..... 4,776,883	2,663,157	4,077,870	3,961,945	33,289

Q. Dr. North, who prepared the Chart No. 5 which you now produce?

A. I did.

Mr. O'Sullivan: I offer the chart marked No. 5, prepared by this witness in evidence and ask that it be marked Complainants' Exhibit number 210.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 210.

The Witness (continuing): Matters of public health must necessarily be considered in their relation to the individual. If the Post Office, Railroad, Telephone and Telegraph must be looked upon as irritations and as exerting an influence by their pressure upon the public health of the inhabitants of New York City, their effect must be exerted upon individuals. The figures already shown have been Office, Railroad, Telephone and Telegraph must be looked upon as reduced to a per capita basis for the years 1890, 1900 and 1910. I submit No. 6, which shows the increase for a period of twenty years from 1890 to 1910 of these various elements of business pressure. The total transactions per capita in the year 1890 were 391.64, and for the year 1910, 965.15; this means an increase of over 140 per cent. in business activity per capita. This increase is shown graphically in Chart No. 6, which is also submitted.

4119 *Summary Increase Business, New York, Twenty Years.*

Yearly Transactions per Capita.

	1890.	1910.
Mail	146	200.75
Telephone	26	450.00
Railways	218	312.
Telegraph	1.64	2.40
Total Transactions	391.64	965.15

From "Telephone Statistics." American Telegraph & Telephone Co. May 1912.

Scientific American Reference Book, 1913.

Transactions New York Post Office Annual Reports. Chamber of Commerce.

Q. Dr. North, who prepared the Chart No. 6, which you now produce?

A. I did.

Mr. O'Sullivan: I offer the Chart marked No. 6 prepared by this witness, in evidence, and ask that it be marked Complainants' Exhibit No. 211.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 211.

The Witness (continuing): The health of the business man has been affected to a greater degree by the growth of corporations than by any other one factor. That form of business organization known as a corporation takes the least account of the personal interest of its employees. Ruled by the Board of Directors and inspired only by the desire to pay the interest on capital stocks and bonds, corporations look upon individuals only as machines to be cast aside as soon as there is any sign in the individual of decreasing efficiency. As a consequence, persons employed by corporations recognize that the corporation is a heartless creature and that to work at top speed and at highest efficiency is their only chance of holding their
4120 positions. The health and vitality of the employees is therefore taxed to the utmost and cannot receive the consideration from the corporation which they receive from private employers. The growth of corporations in any community must, therefore, be looked upon as having a most serious relation to the public health.

In New York State records have not been kept accurately until recent years, and consequently, a full tabulation of the corporations formed cannot be obtained. I submit below Table No. 6A, which is copied from the Second Annual Report of the Secretary of State of New York for the year 1912. I also submit Chart No. 6A, which shows graphically the growth of the number of corporations formed each year as indicated by the figures in the above table.

From these facts it appears that from the year 1901 to 1912, the number of corporations formed in the State of New York each year increased from 2,670 to 8,757 which means a multiplication of about 3¼ times. It is common knowledge that corporations have increased most rapidly in most recent years. Figures are not available for the years previous to 1901. If the rate of increase were the same for the ten years previous to 1901, there would have been formed in the year 1892 only 800 corporations. This would mean that during 20 years previous to 1912 the number of corporations formed in New York State each year had multiplied ten times. When one considers the numerous corporations in the State of New Jersey and in other States which have their offices in New York City, it is not unreasonable from the figures above shown to assume that during the past 20 years corporations formed each year have multiplied at least ten times. Compared with this the population of New York City has only doubled—consequently, there are now five times as many corporations per capita as there were 20 years ago. Assuming that the average number of persons employed by each corporation was the

same 20 years ago that it is today, these figures mean that five times as large a proportion of the community is now employed by corporations as there was 20 years ago.

4121 When one considers the great increase in the size of larger corporations and therefore in the number of persons employed by each, this estimate appears a conservative one. The corporation tax on the health of the business community is the greatest of all taxes. It is a tax on the nervous system and on vitality which is felt most potently in a great metropolis like New York City.

Stock Corporations Formed Each Year, January 1 to December 31, 1901-1912.

From Second Annual Report of the Secretary of State of New York, 1913.

1901	2,670
1902	3,577
1903	3,887
1904	4,420
1905	5,609
1906	6,347
1907	6,599
1908	7,185
1909	8,328
1910	7,998
1911	8,357
1912	8,757

Q. Dr. North, who prepared the Chart No. 6A, which you now produce?

A. I did.

Mr. O'Sullivan: I offer the Chart marked No. 6-A prepared by this witness, in evidence, and ask that it be marked Complainants' Exhibit No. 211-A.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 211-A.

4122 The Witness (continuing): Another increasing tax on the vitality of the inhabitants of New York City, particularly the business men is their habit of sedentary life. This means indoor life and inactive life so far as the muscular system is concerned. The increasing demands upon individuals required his presence at headquarters and in offices to which the various communications before mentioned come, and the habit of physical inactivity and a consequent degeneration of the muscular system and physical energy of business men has resulted.

Authorities are agreed that there is no system of ventilation which can make indoor air as pure as outdoor air in a closed room without

creating a draft, consequently dwellings and offices of New York City contain air which is much inferior for breathing purposes to outdoor air. Indoor life and office life mean the breathing of inferior air with a consequent tax on vitality. As business has increased and office life has increased the effect of impure air has also increased.

Q. Dr. North, what have been the results of the various factors that you have now given in detail on New York City life and on New York City diseases and the susceptibility of citizens of New York City, toward these odor nuisances that you already mentioned?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. As a result of the characteristics of New York City life above mentioned, there has been a great change in the character of diseases from which the inhabitants suffer and in the relative importance of the several causes of death. The activities of sanitary authorities have greatly decreased those deaths which are due to bacteria, namely the so called infectious diseases. On the other hand those diseases which are due to a degeneration of the vitality and of the physical organization have greatly increased in recent years. Also diseases resulting from taxation of the nervous system have greatly increased. These facts are supported by the following evi-
4123 dence: Typhoid fever, being a disease which is most frequently transmitted by water and milk, has been greatly reduced through the activities of the health authorities by the purification of the water supply and the milk supply of New York City. From the annual report of the Department of Health of New York City for the year 1908, figures are taken which show that the decennial death rate in the year 1868 was .31 per thousand, while in the year 1908 it was .17 per thousand, a reduction of more than 50 per cent.

The most important infectious disease from which human beings suffer is Tuberculosis. The deaths from this disease have been greatly reduced through modern methods of treatment and through measures of prevention which have been instituted by the public health authorities. The statistics of the New York Department of Health, published in their annual report for 1908 show that in the year 1868 the decennial death rate from tuberculosis was 3.76 per thousand, while in the year 1908 the decennial death rate was 2.23 per thousand. This is a reduction of more than 40 per cent. If we turn, however, to diseases caused by degeneration and with which bacteria have no concern, we discover a startling state of affairs. The vital statistics of the New York City Department of Health for the year 1908 show that in 1868 the decennial death rate from Bright's Disease was .67, while in the year 1908, the decennial death rate from Bright's Disease was 1.39, an increase of over 100 per cent. Another disease which is due to degeneration is Heart Disease. The vital statistics of the New York City Department of Health for the year 1908 show that in the year 1878 the decennial death rate from Heart Disease in the city was 1.11, while in the year

1908 the decennial death rate was 1.40 an increase of about 27 per cent. These facts are shown in Table No. 7 and are shown graphically in Charts No. 7-A, 7-B, 7-C and 7-D.

4124 *Decennial Death Rate in Infectious Diseases and Degenerative Diseases.*

New York City.

1868-1908.

Infectious Diseases vs. Degenerative Diseases.

Dates.	Typhoid.	Tuberculosis.	Bright's disease.	Heart disease.
1868	.31	3.76	.67	
1873	.31	3.76	.62	
1878	.28	3.58	.84	1.11
1883	.29	3.58	.84	1.11
1888	.20	2.76	1.16	1.28
1893	.20	2.76	1.16	1.28
1898	.18	2.24	1.39	1.38
1903	.18	2.24	1.39	1.38
1908	.17	2.23	1.39	1.40

From Annual Report Department of Health City of New York, 1908.

Q. Dr. North, who prepared the charts Nos. 7-A, 7-B, 7-C and 7-D?

A. I did.

Mr. O'Sullivan: I offer the charts marked respectively, numbers 7-A, 7-B, 7-C and 7-D prepared by this witness, in evidence,
4125 and ask that they be marked respectively, Complainants' Exhibits Nos. 212-A, 212-B, 212-C, and 212-D.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibits Nos. 212-A, 212-B, 212-C, and 212-D.

The Witness (continuing): City life in New York levies its heaviest tax on the nervous system. The capacity of institutions for the insane is constantly increasing faster than the population is increasing. Figures showing the insane from New York City as distinguished from the rest of the State are not available. Figures for the entire State are shown in the Twenty-third Annual Report of the State Commission in Lunacy of the State of New York. From this report it appears that in the year 1889 there were 255.2 patients in institutions for the insane for each 100,000 population. In the year 1911, there were 355 patients in such institutions for each

100,000 population—being an increase of 40 per cent. These facts are shown in Table No. 8 which I submit, and in Chart No. 8 attached. It is in the milder forms of insanity, however, that the greatest increase has occurred. There are more patients outside of the institutions at the present time than in former years. The increase in neurasthenia and melancholy is alarming to the medical profession. The various manifestations of nervousness due to over taxation of the nervous system by attention to business is a matter of common knowledge.

Number of Patients in Institutions for the Insane in New York State to Each 100,000 *Population.*

Year.	Total.
1889	255.2
1890	259.3
1891	265.1
1892	272.3
1893	282.3
1894	288.8
1895	300.8
1896	305.6

4126 (Continued.)

Year.	Total.
1897	312.4
1898	317.6
1899	321.6
1900	327.1
1901	327.3
1902	329.3
1903	334.7
1904	339.7
1905	339.7
1906	341.9
1907	342.6
1908	349.6
1909	352.9
1910	358.3
1911	355.4

Twenty-third Annual Report State Commission in Lunacy, State of New York, p. 214.

Q. Dr. North, who prepared the chart No. 8, which you now produce?

—. I did.

Mr. O'Sullivan: I offer the chart marked No. 8 prepared by this witness, in evidence and ask that it be marked Complainants' Exhibit No. 213.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 213.

The Witness (continuing): My researches regarding the increase in degenerative diseases are supported by the studies of life
4127 insurance companies. The increase in degenerative diseases and in insanity and nervous diseases is fully appreciated by these Life Insurance Companies. Two of the largest Companies have already established departments devoted to a special study of the alarming increasing in American people of the diseases peculiar to American life. In a publication entitled "American Life-Waste," published by the Postal Life Insurance Company, the statement is made—"An analysis of the available statistics shows that a decline in the death rate has occurred chiefly in the diseases of children, and early adult life, and comes almost wholly from tuberculosis, typhoid, diphtheria and other diseases of the communicable class. * * * But the death rate from cancer, kidney, heart and similar non-communicable diseases, against which no warfare has been waged, is not only very high, but in most instances has shown a remarkable increase. * * * Chart No. 8 shows a truly remarkable increase. * * * Chart No. 8 shows a truly remarkable increase in the mortality from degenerative diseases, i. e. affections of the heart, blood vessels and kidneys, dropsy, etc. 104 per cent. since 1880. * * * Chart No. 9 showing a very heavy increase in the mortality from degenerative diseases during the most productive years of life, amounting to 60 per cent. between the ages of 40 and 50." In another publication entitled "The upward trend of Mortality in Middle Life and Old Age" by E. E. Rittenhouse, Conservation Commissioner of the Equitable Life Assurance Society of the United States, the statement is made—"The mortality rate from apoplexy, paralysis, diseases of the heart, circulatory system, kidneys and liver, has heavily increased in the younger as well as in the older groups. The total deaths were 367,700 in 1910." "In Massachusetts the death rate from these causes has increased 86.4 per cent. in 30 years." "In sixteen important cities the death rate from organic diseases of the heart, and from apoplexy, Brights and nephritis has alone increased 94 per cent. in 30 years."

"The death rate of the total population, age 40, and over, has increased, 1910 over 1880:

In Massachusetts and New Jersey, 30 years	21.2%
in 16 Cities, 30 years	25.3%
4128 In 10 states, 10 years (1900-1910)	3.0%

The increase in the proportion of older lives in our population has been very slight and does not account for the increase in the death rate."

While nervous and degenerative diseases are recognized as peculiar to American life, the conditions causing them are greatest in New York City. The Bureau of Records of the Department of Health has just published a tabulation showing the approximate life table

for the City, and the expectation of life of the inhabitants of the City at different ages. This table shows that while there has been an increase in the life of persons below the age of forty years during a period extending from 1881 to 1911, yet during that same period there has been a net loss in the length of life in persons over the age of 40 years. These facts are shown in Table No. 9 and in Chart No. 9, which I submit herewith.

4129 *Approximate Life Table for City of New York Based on Mortality Returns of Triennia* 1879 to 1881 *and* 1909 to 1911.

	Expectation of life.						Gain (+) or Loss (−) in years of expectation.		
	1879-1881.			1909-1911.					
Ages.	Males.	Females.	Persons.	Males.	Females.	Persons.	Males.	Females.	Persons.
—5..	39.7	42.8	41.3	50.1	53.8	51.9	+10.4	+11.0	+10.6
5..	44.9	47.7	46.3	49.4	52.9	51.1	+ 4.5	+ 5.2	+ 4.8
10..	42.4	45.3	43.8	45.2	48.7	46.9	+ 2.8	+ 3.4	+ 3.1
15..	38.2	41.2	39.7	40.8	44.2	42.5	+ 2.6	+ 3.0	+ 2.8
20..	34.4	37.3	35.8	36.6	40.0	38.3	+ 2.2	+ 2.7	+ 2.5
25..	31.2	34.0	32.6	32.7	36.0	34.3	+ 1.5	+ 2.0	+ 1.7
30..	28.2	31.0	29.6	28.9	32.1	30.5	+ 0.7	+ 1.1	+ 0.9
35..	25.3	28.1	26.7	25.4	28.4	26.9	+ 0.1	+ 0.3	+ 0.2
40..	22.5	25.2	23.9	22.1	24.7	23.4	− 0.4	− 0.5	− 0.5
45..	19.8	22.4	21.1	18.9	21.1	20.0	− 0.9	− 1.1	− 1.1
50..	17.2	19.4	18.3	15.9	17.7	16.8	− 1.3	− 1.7	− 1.5
55..	14.5	16.4	15.4	13.2	14.6	13.9	− 1.3	− 1.8	− 1.5
60..	12.2	13.8	13.0	10.8	11.8	11.3	− 1.4	− 2.0	− 1.7
65..	9.9	11.2	10.5	8.8	9.4	9.1	− 1.1	− 1.8	− 1.4
70..	8.5	9.3	8.9	6.9	7.5	7.2	− 1.6	− 1.8	− 1.7
75..	7.1	7.5	7.3	5.3	5.7	5.5	− 1.8	− 1.8	− 1.8
80..	6.2	6.5	6.4	4.1	4.5	4.3	− 2.1	− 2.0	− 2.0
85—	5.4	5.5	5.5	2.0	2.4	2.2	− 3.4	− 3.1	− 3.3
							+24.8	+28.7	+26.6
							−15.3	−17.6	−16.6
							+ 9.5	+11.1	+10.0

4130 Q. Dr. North, who prepared Chart No. 9 which you now produce?

A. I did.

Mr. O'Sullivan: I offer the Chart marked No. 9 prepared by this witness in evidence and ask that it be marked Complainants' Exhibit No. 214.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

Received in evidence and marked Complainants' Exhibit No. 214.

The Witness (continuing): In the people of New York City, we therefore, have to deal with a population which is undergoing the maximum tax of business pressure and upon whom the character of life and work has already begun to show its results in a most alarming increase of degenerative and nervous diseases. It is impossible to conceive of a population more susceptible to damage through alterations in the character of the atmosphere which they breathe. Air pollutions which might have little effect upon the health of persons in more favorable environment will have a profound effect upon the

health of such a population as is found in New York City. Any factors such as an odor nuisance polluting the air of New York City would injure not only the health of the inhabitants but also minimize their efficiency and thereby would affect the prosperity of the entire country.

Mr. O'Sullivan: That is all.

Cross-examination by Mr. Riker:

Q. Do I understand you to say that you do not believe Mr. Johnson's statement that the gas that he mentioned was the most offensive to him?

A. No, sir, I did not say that.

Q. Then you don't mean to be understood as meaning that, do you?

A. I do not know what Mr. Johnson thought.

Q. You read his testimony, didn't you?

A. Yes, sir.

Q. Don't you know what he said he thought?

A. I know what he said he thought.

Q. Do you doubt that?

A. I doubt it, because he qualified his statement at the end
4131 of his testimony.

Q. Then you don't doubt his statement, as he made it, do you?

A. I doubt the truth of it.

Q. You doubt the truth of the fact that he thought that that was the most offensive to him?

A. I don't know how far I can go into Mr. Johnson's psychology.

Q. Well, that is the testimony you were asked to refute?

A. He made the statement that indol was the most offensive gas.

Q. To him; don't you remember that he qualified it by making it a matter of a personal equasion?

A. Well, the record will show whether he did; I can not remember the exact words.

Q. Well, you are testifying in rebuttal or supposed to be testifying in rebuttal as to what he said; you don't remember what he said?

A. I remember he said indol was more offensive than the other gases.

Q. To whom?

A. I don't recollect.

Q. So far as you are concerned you don't consider it the most offensive?

A. Why, I don't base my opinion entirely upon my own experiences with it.

Q. I am not asking you that; I am asking you whether you personally considered it the most offensive?

A. No, I do not.

Q. If Mr. Johnson did consider it so, you don't agree with him; is that all there is to it?

A. That is not all there is to it, no. I know of other authorities who join me in my opinion.

Q. Well, do you agree with it?

A. No, sir.

Q. Now, the injury from odors that you have been asked to testify in regard to, have you noticed any injury to health along the water front in New York that you could trace to a discharge of sewage into the waters of New York Bay?

A. I think the air of New York City has a very intimate relation to the health of the inhabitants.

Q. Won't you answer my question, Dr. North?

A. I think that is a sufficient answer to it.

Q. You think that is the answer to the question? Will
4132 you read my question, Mr. Stenographer.?

The stenographer thereupon read the question.

Q. Now, what answer do you make to it?

A. The records of the Department of Health of New York City show that the health of the people who live in those sections of the City is affected by diseases which are peculiar to New York City and New York City life, all of which are shown in the charts and tabulations which I have submitted

Q. Is that the answer which you want to stand by to that question?

A. Yes, sir.

Q. You have no other answer to make?

A. I think that includes the people who live on the water front.

Q. I ask you again whether there is any disease or any effect upon the health of the citizens of New York, the residents of New York, along the water front, that you personally traced to the odors produced by sewage discharged into the waters of New York Bay?

A. I don't see how that question can be answered in any other way than the way I have answered it. As a sanitarian, I am perfectly familiar with the effect of air on health, and I have personally looked into the records of the City of New York, Department of Health for the purpose of ascertaining whether there are diseases in the City that are caused by the air and pollutions of the atmosphere.

Q. I asked you the direct question as to your personal determination of any injuries affecting the residents along the water front of New York, due to the odors produced by the sewage discharged into the waters of New York Bay; can you give me that?

A. I can only answer the question as I have answered it.

Q. Do you know that all the sewage of New York City is discharged along the water front?

A. Yes, sir.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Do you know whether or not the sewage discharged
4133 from New York City is particularly fresh sewage?

A. Yes, sir, I know that it is fresh sewage.

Q. Were you describing in your testimony the putrescent gases given off by septic sewage principally and their effects on health?
A. Yes, sir.
Q. Are the stevedores and other employees working on the water front particularly noted for physical vigor and as a class small in number?
A. Yes, sir.

Mr. O'Sullivan: That is all.
Mr. Riker: That is all.

Adjourned to June 6th, 1913 at 10:30 A. M.

4134 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWAGE COMMISSIONERS, Defendants.

NEW YORK CITY, June 6th, 1913—10:30 a. m.

Before James D. Maher, Esq., Commissioner.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants;
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

WILLIAM T. SEDGWICK, a witness in behalf of the Complainants, recalled in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Professor?
A. William T. Sedgwick.
Q. Did you testify in this suit before?
A. I did.
Q. Was your attention, Professor Sedgwick, directed to
4135 the testimony given by Mr. Asa Henry Phillips, Mr. William M. Brown, General Henry Martin, Robert and Mr. George A. Johnson?
A. It was, and I examined their testimony.
Q. Have you any knowledge of the Sewage Disposal Works at Washington, D. C.?
A. I have, having visited them with Mr. Phillips, the Engineer in charge.
Q. Will you state whether or not you consider the conditions at

Washington are such as to make that system fairly comparable with the proposed Passaic Valley Trunk Sewer System?

A. I do not.

Q. Why?

A. Because to begin with, Washington being comparatively small city, produces a comparatively small amount of sewage. Moreover this is mostly domestic sewage and remarkably free from trade wastes of all kinds. In the next place, the disposal, made under the surface, is into a tidal river of fresh water. The Potomac River, moreover, is limited above by the so-called Point of Rocks, so that instead of a long, level and deep trench or trough, such as we have in the Hudson River, from the Narrows to Albany or Troy, we have in the Potomac a long and shallow estuary stopped at the upper end. While the Washington sewage is poured into this stream, not as would be the case at Robbins Reef in water of such saltness as enables oysters to grow in the vicinity, but rather many miles above any point at which it is deemed possible to cultivate oysters; that is to say into water virtually fresh. The Washington analogy, therefore, has no value, unless it is proposed to pour the Passaic Valley sewage into the Hudson at some point above Poughkeepsie, and the Washington system is accordingly in no wise comparable with that proposed for the Passaic Valley.

Q. Have you knowledge of any sewage disposal plants, employing sub-surface disposal in salt or brackish waters?

A. I have.

Q. Will you name some of them Professor Sedgwick?

A. Beverly, Massachusetts, Salem, Massachusetts, and Boston are three that I am more or less familiar with.

Q. Will you describe the Beverly outfall and the effects of
4136 the discharge of sewage through that outfall?

Mr. Riker: The question is objected to as not being relattal.

The Commissioner: Note the objection of Defendants' Counsel.

A. The City of Beverly having a population of upwards of 40,000, empty- its sewage into Beverly Harbor, but within a few hundred feet of the shore and at a depth of perhaps 10 feet below low tide. The result is that objectionable conditions have arisen, complaints have been made, and a different system of disposal is now under consideration by Beverly.

Q. Will you describe the Salem outfall and the effects of the sewage discharged therefrom?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The sewage of Salem and one or two manufacturing towns in its vicinity, having a combined population of 50,000 or more, is poured into Salem Harbor, at a point perhaps 2 miles away from the shore front but still inside the Harbor near Great Haste Island. This disposal plant is comparatively new and the sewage is delivered upwards from a pipe which comes nearly to the surface at low tide. The result is that in summer, and especially at low tide,

sewage fields are formed over the outlet and in the vicinity and yachtsmen, of whom there are many at Marblehead, Manchester and Salem, are in the habit of avoiding this particular region when possible, because of the disagreeable sights and odors prevailing in the vicinity of the outlet.

Q. Will you describe the Boston system of sewage disposal into Boston Harbor, Professor Sedgwick?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. In the case of Boston, there are three outlets, the oldest known as the Moon Island outlet from which the sewage of the old City of Boston is discharged, but only upon the ebb tide. In the
4137 Moon Island system, the sewage is held in large reservoirs, between tides and then allowed to flow out rapidly on the ebb tide at what is practically the surface. I have investigated these dispersions of sewage from this outlet and have been able to trace it far down the Harbor and over a wide area, but it is a notable fact that it does not appear to be carried back or upwards towards the City to any great distance, a fact which seems to show that the prevailing movement of the water in Boston Harbor is downward toward the sea. The second outlet in point of age, is that known as the Deer Island outlet, from which are discharged daily about 60,000,000 gallons of sewage, at a point very near the Deer Island lighthouse and the Broad Sound Channel, from a pipe turned upwards and located not much below the level of the sea at low tide. This system was put into operation in 1905 and I have frequently seen in the vicinity large sewage fields, easily perceptible to the eye, and giving off a strong stench of sewage. One of the lighthouse keepers nearby had last year an attack of typhoid fever, which was attributed directly to the sewage. Fishermen are often seen gathered about the outlets, doubtless because fish find abundant food in the sewage. At low tide, a low fountain or spring of sewage can be seen boiling up or rising above the level of the sea like a low sewage water spout. From this outlet sewage is discharged continuously, and is therefore carried necessarily on the flood tide for some distance toward the City. Passengers on steamboats and ships entering or leaving the harbor in summer, at low tide, are often affected by the odors encountered in the vicinity of the Deer Island outlet. The third and latest outlet is that known as the Nutt Island outlet. This is situated in the southeastern part of the harbor, opposite to the Deer Island outlet—which is on the northeastern shore—and it is this which most resembles the outlet proposed at Robbins Reef. As in the case of Deer Island, the outlet is here also below the surface, but in this case, instead of ending just below sea level at
low tide, it is placed some 30 feet below that level, the pipe
4138 which constitutes the outlet proper turning upwards, so that while in operation the stream of sewage is directed toward the surface from the bottom of the harbor. To this outlet goes by gravity continuously, through the whole 24 hours, the sewage of a portion of Boston proper, together with that from the City of

Newton, the town of Brookline, and various other places. The amount at present discharged through this outlet is about 40,000,000 gallons daily. Here, also as at Deer Island, abundant evidence exists at low tide, and especially in warm weather, of the presence of sewage upon the surface of the water. Here, also, a low spring, spout or fountain can be seen at low tide, rising above the level of the sea, caused by the upward rush of the volume of sewage ejected from the pipe. So high and strong is this spout or spring that it is not very easy to drive a motor boat over it, while in the immediate vicinity of the sewage fountain abundant evidences of raw sewage, such as discoloration, pieces of paper, bits of orange peel, particles of rags, oily material and other substances characteristic of sewage, abound upon the surface of the water. Inasmuch as it has been testified in this case that experiments have been made by pumping colored water to various depths in the vicinity of Robbins Reef without causing any appearance of color upon the surface in that vicinity, I recently made an experiment with the aid of assistants, in which I introduced into the trunk sewer leading to the outlet at Nutt Island, at intervals of 10 minutes, various quantities of a powerful dye known as eosine, dissolved in water, and then awaited the arrival of the dye at the sewage fountain in the harbor. As a result I had no difficulty in securing abundant evidence of the ready passage of the dye through the sewer to the surface, the surface of the sea being highly discolored on the arrival of the eosine. This experiment, however, was superfluous, because as I have already stated, there is always at low tide constant and abundant evidence of the arrival of vast quantities of sewage on the surface easily visible to the naked eye.

4139 Q. Professor Sedgwick, will you compare that Boston Sewage Disposal System at the Nutt Island outfall, with the proposed trunk sewer project of discharge contemplated by the Passaic Valley Sewerage Commissioners?

Mr. Riker: The question is objected to for the same reasons.
The Commissioner: Note the objection.

A. The Boston plant is in my opinion, the only one in America, if anywhere, which is to any extent comparable with that proposed for the Passaic Valley, and even the Boston system, closely examined, is so different in almost every respect as to be of but little value for this purpose. To begin with the physical conditions which prevail in Boston Harbor are totally unlike those prevailing in the upper harbor at New York. In the latter we have what is virtually a shallow lake, traversed by a deep trench or trough, this lake being hardly more than an enlargement or local distension of the Hudson River. The East River, as is well known, is essentially an oscillating water pendulum and contributed but little to the circulation of the Upper Harbor. The Hudson River, of which the Upper Bay is virtually an enlargement, is a mere long, level and deep trench or fiord extending from the sea to Albany or above, tidal effects being felt as far away as Albany and the water being brackish as far at least as Poughkeepsie. The Kill van Kull and

Newark Bay are comparatively shallow and comparatively unimportant. Boston Harbor, on the other hand is in no sense a river or an enlargement of a river, but rather a broad bay filled with islands, a dozen or more in number, and provided with abundant openings to the sea, two of which at a considerable distance apart, are deep ship channels, through which the waters of the harbor can circulate freely. One of these, the Main Ship Channel, debauches to the east, the other, the Broad Sound Channel to the northeast, while a third, narrow but deep, and known as Shirley Gut, when the wind is north or south, contributes materially to the harbor circulation. Moreover, Boston Harbor has at its upper end,
4140 no tidal reservoir comparable with the great Hudson River, but ends quickly in several small streams or bays, so that the general configuration of the harbor may be likened to the palm of a hand, ending above in short and comparatively insignificant fingers, but opening below by a wide wrist-like connection with the sea.

From all this it follows that winds, from various directions materially influence the circulation of the waters of the harbor and contribute materially to whatever success may be claimed for the Boston system. These physical features, therefore, make the Boston system absolutely different from any which it is possible to create in the Upper Harbor of New York. One other condition of great importance must be mentioned, and that is the difference in the rise and fall of the tides, those at New York ranging from 3 to 6 feet only, while those at Boston range from 6 to 13 feet. So that, the fresh-ning action of the tides is obviously about double in Boston what it would be in New York. The absence also, as already indicated, of any capacious tidal prism or reservoir in Boston comparable to that furnished by the Hudson River, doubtless keeps the sewage largely in the Lower Harbor at Boston and forbids its carriage by the flood tides far inland as happens in New York. It would also appear that the Boston sewage at least at the Nutt Island outlet is much less septic than the Passaic Valley sewage would be, since only 6 or 8 hours appear to be necessary to bring the principal flow to the Nutt Island outlet, while at least double that time would probably be required to bring that of the Passaic Valley to Robbins Reef. Another item of difference is the fact that whereas the Hudson River is itself heavily polluted with sewage, whatever water finds its way into the upper portions of Boston Harbor is comparatively pure.

Q. Professor Sedgwick, do you know of any system anywhere so closely resembling the proposed Passaic Valley Sewerage System as to enable any one to predict with certainty that the latter will be successful?

A. I do not.

4141 Q. In your opinion is the Passaic Valley Trunk sewer project an experiment?

A. It would certainly be an experiment, but not an experiment in which the chances of success or failure would be equal. On the contrary in my opinion from what we know about other systems,

of disposal, into salt water, taken together, with the conditions existing in the Upper Bay at Robbins Reef, I consider it a very dangerous experiment and one probably doomed to early failure.

Q. Why?

A. For the reason that the Upper Harbor is already heavily and dangerously polluted with sewage, so that to add to the burden of filth, which it already carries, that which would inevitably come from the Passaic Valley, would be to invite disaster.

Q. What do you mean by "invite disaster"?

A. I mean to so increase the burden of filth already borne by the water of the Upper Bay as to exhaust its powers of oxidation, which are already seriously impaired, at times, thereby bringing on a condition of putrefaction which would turn the Upper Harbor and a considerable portion of the Hudson River, into a body of sewage, a kind of cesspool, in which neither fishes nor vegetable life could exist, and from which nauseous, disgusting and dangerous odors, due to the gases of putrefaction, would arise, creating a menacing odor nuisance.

Q. What effect, if any, would this malodorous condition have upon the public health?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It would, I believe, diminish vital resistance to disease and cause lassitude, loss of sleep, headaches, malaise, and possibly even nausea at times among people living within its reach, that is, within the Metropolitan district. My reason for holding this opinion is that I have myself lived at one time adjoining the Back Bay water of Boston, and that I have been obliged sometimes, at night, to close the widows of my apartment, because of
4142 the nauseating odors proceeding from the sewage polluted water which formerly at low tide filled that Bay. I have also known of similar nausea and sickness produced by the sewage polluted Blackstone River at the Town of Millbury, and it is a well known fact that steamboat men and passengers have sometimes at low water in sewage polluted rivers, been taken violently ill from the stench in the rivers. It is also agreed among sanitarians that the pollution of foreshores and coastal waters with sewage is a menace to the public health. It has been observed, for example, that on the English coast, the crude sewage upon the foreshores appears to have caused a very much higher mortality from typhoid fever than existed in other parts of the country, an excessive mortality, which has been attributed by competent authorities to the coastal pollution. Sore throats have also been observed to prevail in the vicinity of highly polluted sewage polluted sea waters. Other ailments which have been noted in such cases are diarrhea, prostrations, headaches, loss of appetite and a general lowering of health with malaise. These conditions prejudicial to the public health appear to be due to what are sometimes called effluvium nuisances; that is to say gases arising from putrefying mixtures of sewage and water, or to sewage deposits from either or both of which sulphuret-

ted hydrogen and other poisonous gases readily arise. When these deposits are laid bare by the tides if that happens there is also danger of insect transmission of living micro-organisms from the mud to people in the vicinity. So that, summing it all up, we may say that while it is often difficult to prove any increase in the presence of infectious diseases from exposure to sewage polluted waters, sinking waters or exposed flats, such increase has in fact, in my opinion, reasonably contributed to these causes and constitutional effects are unquestionable, for, as I say, I have myself witnessed and experienced some of them.

Mr. O'Sullivan: Your witness.

4143 Cross-examination by Mr. Riker:

Q. What is the population of Washington?
A. Washington?
Q. Yes.
A. 350,000.
Q. At what point is the locality of the rocks with reference to the city?
A. It is opposite the upper end of the City.
Q. What is the volume of the Potomac River at Washington?
A. I don't know.
Q. Do you think that the Potomac River at or above Washington is as desirable a place to dispose of sewage of 350,000 inhabitants as Robbins Reef?
A. Why, yes, I think so, more desirable.
Q. More desirable? Why?
A. Because the stream is mainly downwards.
Q. Is it a tidal stream?
A. Yes.
Q. How high does the tide rise at Washington?
A. I do not know exactly, but it is low, two or three feet.
Q. When the tide rises is the water backed up along the shores of the City of Washington?
A. To some extent, yes.
Q. Do you think that without reference to the volume of the water in the Potomac River, that it is as desirable a place to discharge sewage of 350,000 inhabitants as Robbins Reef?
A. I think so, because that backing up is only occasional, the river is a big river, most of the stream is downward; besides they have got to put it somewhere and that seems to be one of the best places.
Q. You are now dealing with the argument of necessity, are you?
A. Well, I mentioned that, yes.
Q. Is that the reason why you think the disposal at Washington is not comparable with that at Robbins Reef?
A. No, that is not the main reason; it is one reason. Robbins Reef is not the only possible place by any means.
Q. But leaving the question out entirely of any surrounding

cities, and dealing purely with the effect upon the water it-
4144 self, you think that it is as desirable to discharge the sewage of 350,000 people into a water of the size and character of the Potomac River as to discharge it at Robbins Reef?

A. Well, I suppose you mean as to the discharge of the Passaic Valley at Robbins Reef?

Q. No, I am talking of the same population?

A. Of the same population?

Q. Yes.

A. That is a question of course, that I have not considered. As desirable, I think you said; wasn't that it?

Q. Use any expression you want, Professor; I don't insist upon splitting hairs in this question; I want to know as to the effect upon the water?

A. Oh, I think it is desirable. I think it would have a less effect upon the water. I think it is more desirable and would have a less effect upon the water of the Potomac River than it would at Robbins Reef.

Q. And why?

A. Because the water of the Potomac River is almost constantly moving downwards, so that the dilution would be rapid with the oxygen loaded water, and the thing is in fact well taken care of down below and the conditions seem to me so different, that I should rather put it in at Washington than at Robbins Reef, under present conditions.

Q. And having observed the effects of the Washington disposal and finding that they are not injurious, you think the conditions are better for the discharge there, isn't that all your testimony means?

A. I did not say that they are not injurious, at least, if I did, I should not have said so. I said that in my opinion and I will now say in my opinion they do not conspicuously affect the water there, but they have caused a great deal of trouble with the oysters below, they are alleged to have caused, and while the thing works superficially pretty well, I do not like that kind of a disposal anyhow, and I would like to get rid of it. But if I had to choose between the two, I would rather put it in there than at Robbins Reef.

Q. What is the flow of the Potomac River?

A. I don't know.

Q. Didn't you say that one of the reasons was because of
4145 the superior dilution of the Potomac?

A. No, I said it was a steadily downward flow. Yes, dilution, that is so.

Q. Well, if the flow was an inconsiderable amount, even though it is downward, do you think that affects dilution?

A. No, it is not inconsiderable.

Q. Do you know what the flow is?

A. No, I do not.

Q. How can you testify as to the dilution then?

A. Because I have seen it.

Q. Do you know the amount of it?

A. No.
Q. Have you seen the location at Robbins Reef?
A. Yes.
Q. Do you know what the dilution is?
A. No.
Q. Do you know the flow there?
A. No.
Q. Then how are you ever to testify as to the relative dilution then?
A. I did not say anything about it.
Q. What is there in the condition of the Potomac River that renders it superior for digesting sewage than the water of Robbins Reef?
A. Oxygen.
Q. In what respect and how does it happen that the oxygen of the Potomac River is superior to that of New York Bay at Robbins Reef?
A. The oxygen is not superior.
Q. Well, then, in what respect is the oxygen more effectual in the Potomac?
A. Because the stream is less polluted and therefore contains more oxygen.
Q. It is less polluted than the waters of Robbins Reef?
A. Above Washington, yes, when it comes down to the point of the sewage.
Q. How much less?
A. I don't know.
Q. How can you testify, then, if you do not know?
A. Because anybody can see it.
Q. Can you tell how much oxygen there is in water by looking at it?
A. I can tell how much pollution there is by telling how many towns and cities there are.
Q. Is there any other element in the water of the Potomac
4146 River that makes it superior in oxygen, so far as you know to Robbins Reef?
A. It is fresh water.
Q. To what extent does that create any superiority?
A. I don't know what percentage, but a certain extent.
Q. Well, give us an idea?
A. I have not any.
Q. Twice as much?
A. No, I should say not.
Q. Well, 50 per cent. more?
A. I do not know.
Q. 20 per cent. more?
A. I don't know.
Q. You don't know anything about it?
A. I don't know very much.
Q. You are testifying as an expert in this case, are you not?
A. I am trying to.
Q. Have you examined the outfall at Washington?

A. I have.
Q. How recently?
A. Last January, I think it was.
Q. You read Mr. Phillip's testimony in this case?
A. Yes.
Q. Do you disagree with him as to his observations of the effects?
A. Not at all.
Q. He is in charge of those works, isn't he?
A. Yes.
Q. What is the treatment given to the sewage of Beverly before it is discharged?
A. No treatment.
Q. None at all?
A. No.
Q. Not even screening?
A. Well, possibly a little screening.
Q. Well, do you know whether it is?
A. No, I do not.
Q. What is the treatment given to the sewage of Salem before it is discharged?
A. I don't think any is given unless it is a coarse screening, which is practically nothing.
Q. Do you know whether it is or not?
A. No, I do not. I suppose that——
Q. I did not ask you to guess; I want to know what you know about it. Why do you compare those outfalls with the proposed outfall at Robbins Reef from the Passaic Valley Trunk sewer?
A. Simply because outfalls of any size which are into salt water are few and I have had to take what I could find.
4147 Q. Ever been abroad?
A. Yes.
Q. Visited the Hamburg works?
A. No.
Q. The Dresden works?
A. No.
Q. The Frankfort works?
A. No.
Q. The Birmingham works?
A. Yes.
Q. When did you visit them?
A. It was 10 years ago.
Q. Where does that discharge?
A. Well, at that time they were using filters; it went on sewage filters.
Q. Do you know that has been abandoned?
A. I believe it has, yes.
Q. Do I understand you to state, in your opinion, the conditions in Boston Harbor are more favorable for digesting sewage and for safe assimilation of sewage than New York Harbor?
A. I think so, very much.
Q. And you have given your reasons?

A. I have tried to, yes.

Q. And the reason why New York Bay is inferior is because of the long trench or fiord, as you called it, reaching from the sea up to about Albany or Troy, is that it, one of the reasons?

A. That is one of the reasons.

Q. Where does the sewage from the Greater City of New York discharge now?

A. All along the shores of Manhattan and Brooklyn.

Q. How many inhabitants are there in the greater City of New York?

A. Did you say the Greater City?

Q. Yes.

A. I believe about five or six millions.

Q. How many are there on the New Jersey shore; how many people?

A. I don't know; I know that the Metropolitan District has perhaps six and a half or so.

Q. Six and a half millions?

A. Yes.

Q. How is this mass of sewage disposed of, if you know?

A. From Manhattan and Brooklyn as I stated, and from New Jersey by similar discharges along the shores.

Q. Right into the waters of the New York Bay?

A. Right into the waters, yes, and Newark Bay.

4148 Q. But, confining your attention now for the purposes of my examination to New York Bay, have you examined the disgusting and odorous conditions which you have described to have been observed by you in Boston Harbor?

A. I have.

Q. Existing in New York Harbor?

A. I have.

Q. Where?

A. Along the shores of New York City.

Q. Anywhere else?

A. In Brooklyn, of course; that is all.

Q. Anywhere else?

A. No, I think not.

Q. Do you find them out in mid-stream in the East River?

A. Yes.

Q. In the mid-stream of the Hudson River?

A. No.

Q. You do not find them there at all, do you?

A. I have not, no.

Q. Have you been across the Hudson River a great many times?

A. Not particularly to study the Jersey side; of course, I have been across many times, but not while looking for these things.

Q. How do you account for the successful disposal of New York City then?

A. I don't think it is very successful.

Q. Are there any epidemics that you know of that have arisen?

A. No.

Q. Any typhoid visitations in New York City from the sewage so far as you have heard?

A. Not that I know of; there may have been though.

Q. Do you know that the health of the City of New York as disclosed recently with reference to typhoid is way beyond the average?

A. Very good, yes.

Q. So much so that they have abandoned the project of filtering the Croton water?

A. I did not know that.

Q. You have not heard that?

A. No.

Q. Well, do you know that they have abandoned the project of filtering the new water supply because of the superior health conditions existing?

A. The last I knew was that they were going to filter it.

Q. Don't you know that they have abandoned it?

A. No, I did not know that. I ought to say, however, in
4149 connection with what I have just said regarding typhoid, that while the rate of New York is creditable with the rest of this country, it is not particularly creditable as compared with the best of other countries.

Q. You have mentioned a typhoid fever case at Deer Island?

A. Yes.

Q. Did that come under your personal observation?

A. No.

Q. Do you know anything, as a matter of fact, of the causes of it?

A. No.

Q. Do you know anything of the history of it from your own knowledge?

A. No.

Q. What do you know?

A. I only know it is said to have come from that sewage.

Q. Did you ever hear the story of the Three Black Crows?

A. I dare say; I don't remember now.

Q. You passed up and down the Hudson River at frequent intervals, haven't you?

A. Occasionally, yes.

Q. Have you ever been injuriously affected by the obnoxious and offensive odors discharged into the Hudson River and Upper New York Bay?

A. Not to my knowledge.

Q. Now, you have been asked to predict the conditions which will arise from the proposed discharge from the Passaic Valley sewer at Robbins Reef; what do you understand the proposed discharge is?

A. You mean in volume?

Q. No, I mean in every respect. Let me hear what the elements are as to which you are predicting consequences?

A. Why, I understand that the sewage from the Passaic Valley is to be collected and held for a time and screened with a good deal of care and then discharged through a tunnel at Robbins Reef.

Q. Is that all?

A. Well, it is to be discharged in a particular way through comparatively small apertures, extending over a large area.

Q. Well, what other elements are there in the problem as it is presented to you to predict as to the consequences?

A. I think that I have stated the important ones.

Q. You don't lay any importance on sedimentation?

4150 A. I said it was to be held. I assume that during holding there would be sedimentation. The only object of holding it is to get sedimentation.

Q. You said it was to be held and screened?

A. Yes.

Q. Do you understand it is to be held and screened or screened and held?

A. I presume it will be screened and held.

Q. And that is what you understand is proposed?

A. That is what I understand is proposed.

Q. Do you understand that it is proposed to produce an effluent from the disposal plant, which when discharged into New York Bay will result in the absence in the New York Bay of visible suspended particles, coming from the Passaic Valley sewer?

A. I am aware that is one of the proposals yes.

Q. Is it an effluent of that character that you are predicting the results of?

A. Naturally it could not be.

Q. Well, then, why do you testify as to the proposed discharge having the effects which you have already stated?

A. Because I do not believe that it can be practicable to produce the condition mentioned by you just now.

Q. In other words, you don't believe that it is proposed to produce an effluent of the character stipulated in this Complainants' Exhibit No. 135, being a stipulation between the United States of America and the State of New Jersey and Passaic Valley Sewerage Commissioners?

A. Of course, I understand that that is proposed, and if I believed that that could be done and that would really in effect be what would happen, I could have no objection, of course.

Q. Well, do you doubt that that is what is proposed to be done?

A. No, I do not doubt it is proposed by New Jersey.

Q. Then why do you say that the proposed discharge will result as you have testified?

A. Because I do not believe that the thing proposed can be carried out.

4151 Q. Well, do you wish to modify your testimony?

A. No.

Q. You still wish to say that the discharge as proposed will result as you have testified?

A. I think so, yes.

Q. Notwithstanding the fact that the proposal is to produce an effluent from which there will be an absence in New York Bay of visible suspended particles, of sewage?

A. Notwithstanding that, yes.

Q. Do you understand that it is proposed to produce effluent which when discharged into New York Bay at Robbins Reef will result in an absence of deposits objectionable to the Secretary of War of the United States, in the New York Bay, coming from the Passaic Valley sewage?

Mr. O'Sullivan: I object to that question; it calls for a psychological determination by this witness, which he has not qualified himself to give.

The Commissioner: Note the objection of Counsel for the Complainants.

A. I do understand that; yes, sir.

Q. And notwithstanding that you say that in your opinion the proposed discharge will result in the consequences which you testified to in your direct examination?

A. I do.

Q. Well, Professor, will you please define "proposed" as you are using it in your testimony?

A. Why, I understand by the "proposed" scheme as it is taken in a larger sense by engineers. There are many limitations to the word "proposed"; one man has one idea in his mind, and another man has another. I understand by proposed a scheme which will take the sewage and pour it out as I have said; and what another man or set of men may mean by it, I cannot say.

Q. Well, when you use the word "proposed" in connection with the discharge from the Passaic Valley Sewer, you use it, do you not, in direct disbelief of the effluent which will result as specified and agreed in the stipulation in question?

A. I do.

4152 Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Professor Sedgwick, in what condition would you expect the Passaic Valley sewage to reach the Newark Meadows after several pumpings, and after many hours in transit?

Mr. Riker: The question is objected to on the ground that it is not redirect examination of any examination on the cross.

The Commissioner: Note the objection.

A. I should expect it to arrive finely divided and already freed from heavier suspended particles, such as sand and things having high specific gravity, but passing very rapidly through screens. This is in fact the way in which the sewage arrives at the Nutt Island, very little being held back by the screens.

Q. Will the great mass of that sewage pass through a screen 4/10ths of an inch in mesh?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It certainly will.

Q. What condition would you expect the sewage to be in as to septicity when it reached the sedimentation tanks?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. In summer I should expect it to be destitute of oxygen and often in a stinking, rotten condition, a condition commonly described as distinctly septic.

Q. Those finely divided suspended particles that you described in your previous answer, are they particularly putrescible?

Mr. Riker: Same objection.
The Commissioner: Note the objection.

A. Some of them are, because attached to them are fre-
4153 quently clusters of bacteria, feeding upon the organic matters. Some of them are not particularly so.

Q. Are they readily sedimentable?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. Not very, no; they float pretty readily.

Q. Professor Sedgwick, handing you Complainants' Exhibit No. 135, I ask you if the plant described in that exhibit will produce the effluent or rather the effects guaranteed from the effluent as stipulated for in that exhibit?

A. I don't believe that they would.

Q. In reply to a question put to you by Mr. Riker relative to the typhoid fever case which you mentioned as occurring to the light house tender in Boston Harbor, I ask you if you have any direct knowledge of other typhoid cases directly traced to manipulating the sewage at that outfall?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I have. Two of my students, in doing a piece of work upon Boston sewage together for investigation, came down with typhoid fever and careful investigation seemed to exclude all other known causes than the sewage upon which they were working. I therefore was forced to believe that they contracted the fever from the sewage.

Q. What were the names of those two students?

A. Mr. Saville, now a partner of Mr. Rudolph Herring and Mr. Greeley now Assistant Chief of the Sewage Experiment Station in Chicago.

Q. Contributing to the pollution of New York's Upper Bay, what riparian cities in the State of New Jersey are there?

A. I am not sure that I know them all, but of course, Jersey City, Hoboken and whatever cities, if any, between them, and the state line.

Q. Is the oxygen content of fresh or brackish water higher?

A. Of fresh water.

4154 Q. Is the sewage digestive capacity of fresh or brackish water highest?

A. Fresh water is higher in digestive capacity.

Q. Is the Potomac River a large or a small river?

A. Very large river.

Q. How is it as to salinity?

A. It is fresh at the point of disposal of the Washington sewage.

Q. Is the current swift enough to take whatever sewage is discharged into it, some considerable distance before depositing it?

A. Generally so, although that of course depends on the tide and upon the flood conditions in the river.

Mr. O'Sullivan: That is all.

Cross-examination by Mr. Riker:

Q. What do you know about the rapidity of the Potomac River; how fast does it run?

A. Well, of course at the sewage station, it may stand still.

Q. I did not ask you that; I asked you what is the flow of the Potomac River?

A. I will say then that I do not know.

Q. Is it possible to produce an effluent from the sewage of the Passaic Valley District, which will result as guaranteed in the stipulation which is Complainants' Exhibit No. 135 in your opinion?

A. I think so.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Has such an effluent ever been produced by the treatment of septic sewage anywhere in the world, that you ever knew of, Professor Sedgwick?

A. I did not understand the question to be purity at Robbins Reef under this system. I understood Mr. Riker's question to mean whether it was possible to so purify the sewage coming from the Passaic Valley as to fulfill the conditions mentioned in the stipulation. I do not see any practicable way of purifying the sewage at Robbins Reef except at extraordinary expense and under enormous difficulties, both physical and chemical, and I do not know of any
4155 city or town which produces and then purifies a sewage so septic as I believe this would be when it arrives at Robbins Reef.

Q. Is it an advantage or a disadvantage to treat sewage near the source of its origin?

A. Generally speaking, a great advantage.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. Repeat the answer, Professor: in your opinion is it possible to treat the sewage of the Passaic Valley in such a way as results in an effluent which will result as guaranteed in the stipulation?

A. Yes, I think it is.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Would you say whether or not the expense attending the production of such an effluent as stipulated for here in Complainants' Exhibit No. 135, would be prohibitive or not, in price or cost?

Mr. Riker: The question is objected to on the ground that it does not deal with the issue in this case; the complainants in this case having no possible concern with the expense.

The Commissioner: Note the objection of Counsel for the Defendants.

Mr. O'Sullivan: The question is pressed by Complainants' Counsel for the reason that it has been testified to by this witness that it is not feasible to produce an effluent stipulated for or the results guaranteed in Complainants' Exhibit No. 135, and that as there is a provision in the second paragraph "Or other requisite, lawful additional arrangements" the question is pressed for the purpose of determining whether or not such additional arrangements may or may not be prohibitive and unlawful on the item of expense.

A. I wish to state in order to be perfectly clear, that I do believe it perfectly possible to purify the Passaic Valley sewage in
4156 - such a way that the effluent could be put into New York Harbor or anywhere else and produce no harm; but I do not believe that it could be done by the scheme referred to which discharges at Robbins Reef. I believe it would have to be done either on the Newark Meadows or Newark Bay or somewhere; and of course at very great expense. I do not believe that that would be prohibitive; I believe it would be very large. I believe that cities and towns are going to purify their sewage even at very great expense in the future, and in order to be still clearer if I can, I mean to say that I believe that to purify the sewage, which it is now proposed to bring to Robbins Reef under the stipulation referred to, either at that point, or at some neighboring point on the shores of New York Bay, would not be practicable. I do believe it would be practicable to purify it in Newark Bay, taking it before it gets septic and having filter beds there, and that is what I believe ought to be done. I am not sure that I answered your question.

Mr. O'Sullivan: That is all.

Redirect examination by Mr. Riker:

Q. Well, Professor, don't you understand that the purification plant is located at the Newark Meadows adjoining the Newark Bay?
A. I understand that the sedimentation and screening plant is, yes.
Q. The purification works that are contemplated:
A. So far as contemplated, yes.
Q. On the Newark Meadows; at about the point you indicated?
A. I should say so, yes.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Are those purification plants consisting of sedimentation and screening sufficient for the purification of the sewage?
A. Not in my opinion.

Mr. O'Sullivan: That is all.

4157 Recross-examination by Mr. Riker:

Q. You think there might be added some filter beds to advantage?
A. Filter beds or other appliances, yes.

Mr. Riker: That is all.
Mr. O'Sullivan: That is all.

Adjourned to June 17th, 1913 at 10:30 a. m.

Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Before James D. Maher, Commissioner.

NEW YORK CITY, June 24th, 1913—10:30 a. m.

Appearances:

William P. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants;
Adrian Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

4158 EDWARD ELLERY, a witness in behalf of the Complainants, re-called in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Professor?
A. Edward Ellery.
Q. Did you testify in this case previously?
A. I have.
Q. Professor Ellery, have you read the testimony given by Mr. George A. Johnson, a witness called by the Defendants in this suit?
A. Yes, and with particular reference to that part of his testimony that relates to a certain dye experiment performed by him, November 19, 1907.
Q. Will you state what you noted especially in that part of his testimony relating to the dye experiment?
A. I noted:—
1. The dye used was so called red R dye.

2. The strength of the dye solution was a little more than 1 part in 12,500.

3. The direction of the discharge of the solution was vertically downward.

4. The direction of the current on the surface and on the bottom at the time of the discharge into the 30 foot depth was the same and the velocity was the same.

5. At the time of the discharge into the 40 foot depth, the current at the surface was of greater velocity than at the bottom but in the same direction.

6. The maximum of sewage discharge in the proposed plan is to be 360,000,000 gallons per day.

7. The salinity of the water at the time of the discharge of the dye solution was 8500 parts chlorin per million.

8. A quotation is made from the report of the Metropolitan Sewerage Commission for 1910, pages 457 to 460, relative to results of a certain dye experiment performed by the Commission.

4159 9. A quotation is made from a report of the U. S. Coast Survey for 1873, page 129, relative to tidal velocities off Robbins Reef, showing mean surface velocity of flood tide to be 0.35 feet per second, average minimum velocity of flood tide at all depths 0.29 feet per second, and average minimum velocity of ebb tide at all depths 0.52 feet per second.

10. A quotation is made from the report of the Metropolitan Sewerage Commission for 1910, page 155, relative to tide velocities.

11. Mr. Johnson states that tide velocities have not changed to his knowledge between 1892 and 1907.

12. Mr. Johnson draws an inference on the result of one dye experiment that fresh water sewage discharged as proposed through outlets, some 150 in number and located at a depth of 40 feet or more below the surface will undergo sufficient complete diffusion in the waters of New York Bay so as not to raise to the surface in objectionable quantities if at all, and rarely if at all in visible quantities.

Q. Will you state fully what studies and investigations of a scientific character you have submitted these enumerated items of Mr. Johnson's testimony to, Professor?

Mr. Riker: The question is objected to as not being rebuttal.

The Commissioner: Note the objection of Counsel for the Defendants.

A. The dye solution was less than ½ as strong as the weakest dye solution used by the Metropolitan Sewerage Commission in its dye experiments. Mr. Johnson's solution was 1 part to 12,500. The weakest solution of the Metropolitan Sewerage Commission was that of Special Scarlet, a dye in every way similar to the so called Red R dye, its solution was 1 to 5000 parts.

4160 1. The testimony of Dr. Soper, given in this case at pages 4276 and 4279 shows that the dye used by the Commission for its deep water experiments was uranin, a dye that is very much more persistent, that is, it is visible in far greater dilution than either

Special Scarlet or the so called Red R dye. It is visible in a dilution of 1 part to 30,000,000 parts.

2. Mr. Johnson gives no data to show whether the water at the points of discharge was of different degrees of salinity at different depths.

3. Reference to the place in the report of the Metropolitan Sewerage Commission for 1910, at page 155, where current velocities are given, from which Mr. Johnson quotes, shows that no velocities are given for the current off Robbins Reef.

4. Without further data than are given in his testimony, Mr. Johnson's opinion as to what will happen when fresh water is discharged into salt water is unreliable and his conclusion is erroneous.

Q. Will you give the facts supporting your statement that Mr. Johnson has given insufficient basis for his conclusions from his dye experiment and that his opinion is erroneous, Professor?

A. The grounds for these statements are experimental studies I have made on the effect of salinity and direction of discharge on the ascent of fresh water in salt water. These experimental studies consisted of discharging fresh water, made with a solution of dye in the same strength as that used by Mr. Johnson in his experiments, in salt water of varying degrees of salinity, and discharging that fresh water in different directions, downward, laterally and upward. The report that I make on those experimental studies includes series of photographs showing the effect of direction of discharge on the ascent of the fresh water in the salt water and also the effect of different degrees of salinity in different depths. The report includes
4161 a photograph showing the effect of discharging a dyed fresh water in an upward direction in salt water of the same degree of salinity as that which Mr. Johnson states existed in the water at the time of his experiments. The report describes the way in which these experiments were performed, the salinity of the waters, the apparatus used, and the results of the different series of experiments. The series of experiments were:

1. Effect of direction of discharge of fresh water into salt water when the latter is of the same degree of salinity throughout;

2. The effect of delivering fresh water in an upward direction into salt water, consisting of layers of different degrees of salinity; and

3. The effect of delivering fresh water in a downward direction into salt water consisting of layers of different degrees of salinity. The results of each series are tabulated and the conclusions from each series are given at the end of the description of the individual series, and at the end general conclusions from all the series and from the experimental studies, in general.

Q. Who conducted these experimental studies?

A. I did.

Q. Who prepared the report that you have just described?

A. I did.

Mr. O'Sullivan: I offer the report just described by this witness in evidence, and ask that it be marked Complainant's exhibit No. 216.

Mr. Riker: The offer is objected to on the ground that the report is not proper evidence, is immaterial, irrelevant, and not rebuttal.

The Commissioner: Note the objection of Counsel for the Defendants.

Received in evidence and marked Complainants' exhibit No. 215.

Q. Will you state what conclusions you reached from you experimental studies on the effect of salinity, and direction of discharge on the ascent of fresh water in salt water?

Mr. Riker: The question is objected to as not being rebuttal of any evidence of the Defendants.

The Commissioner: Note the objection of Counsel for the Defendants.

4162 A. 1. If the salt water is of the same degree of salinity throughout its depth, fresh water delivered into it at the bottom will come to the surface whatever the direction of discharge.

2. A slight difference in salinity at different depths is sufficient to prevent fresh water from rising to the surface when it is delivered in downward direction in the lower stratum.

3. The conditions which will prevent fresh water from rising to the surface when delivered in the lower stratum in a downward direction will not prevent the fresh water from rising to the surface when delivered in the lower layer in an upward direction.

4. Therefore, what happens when fresh water is discharged in downward direction in lower layers of salt water is not a criterion of what will happen when the same fresh water is delivered in the same layer in an upward direction.

Q. Will you apply these conclusions to the conditions of salinity of the water off Robbins Reef?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

A. The report of the Metropolitan Sewerage Commission for 1910, page 527, contains a table and subjoined statements showing the salinity at Robbins Reef at different depths.

4163

Date, 1909.	Time.	Surface.	Per cent. land water. 20 ft. depth.	40 ft. depth.
August 23.	10:45 A. M.	40	36	28
	12 M.	34	30	24
	1:15 P. M.	34	26	24
	2:00	32	28	26
	3:00	34	24	24
	3:30	28	26	26
	4:15	32	24	20
Sept. 1.	11:00 A. M.	20	16	16
	12 M.	24	20	20
	1:00	26	22	22
	2:00	22	24	22
	3:15	24	26	24
	4:15	28	26	26

There is a quotation from that report joined to the table as follows:

"The difference between the salinity of the water at the surface and at a depth below the surface of 40 feet was found more marked at Robbins Reef than in most other places. * * * but this condition was variable. A sample taken at Robbins Reef October 30, at 4 P. M. had a specific gravity of 1.025 indicating an entire absence of land water."

There is a further quotation, as follows:

"The amount of land water (December, 1909), at slack high water varied from 14 to 32.4 per cent, and at slack low water from 12 to 36.4 per cent."

From this table and these quotations in the light of my experimental studies the inference may be drawn, that:

1. If fresh water were delivered in downward direction in the lower layer of water off Robbins Reef at any time August 23, 1909, between 10:45 A. M., and 4:15 P. M., it would not have come to the surface.

While if it were discharged in an upward direction in the
4164 lower layer at any hour except the first, namely 10:45 A. M., it would have come to the surface. And it might also have come to the surface at the other, the first period, depending on the velocity of the discharge.

2. If fresh water were delivered in downward direction in the lower layer of water off Robbins Reef at any time between 11:00 A. M. and 4:15 P. M., on September 1, 1909, it would not have come to the surface.

3. If fresh water were delivered in any direction, downward, sidewise, or upward, in the lower layer of water off Robbins Reef, at 4 P. M. October 30, it would have come to the surface.

Q. Professor, are the conclusions reached from your experimental studies supported by other evidence?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The report of the Metropolitan Sewerage Commission for 1910, page 460, states, regarding the results of its dye experiments:

"In 29 cases out of 66, the sewage came at once to the surface: in 31 cases no effect was visible: in 6 cases the result was doubtful."

It is evident from these results that there are conditions which at times prevent the dye solutions discharged in downward direction in the lower layers from coming to the surface. It is further evident from these results that the inference that fresh water sewage discharged as proposed through outlets, some 150 in number and located at a depth of 40 feet or more below the surface, will undergo sufficient diffusion in the waters of New York Bay so as not to raise to the surface in objectionable quantities if at all, and rarely, if at all, in visible quantities, is erroneous.

Q. Have you any further evidence that supports the conclusions reached from your experimental studies?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

4165 A. In his testimony, pages 4276 to 4279, Dr. Soper gives the details of some of the dye experiments of the Metropolitan Sewerage Commission.

The experiments of dates June 15, July 30, July 31, August 2nd and August 3, 1909, give no details as to salinity.

The experiments of August 5, 6, and 13 give salinity determinations, but in these instances, the fresh water was delivered at different depths.

August 11, fresh water dye solution discharged at 35 feet, the salt water showing three distinct layers of different salinity, no color appeared on the surface.

August 18, fresh water dye solution discharged at 30 feet, the salt water showing two distinct layers of different salinity, no color appeared on the surface.

August 26, fresh water dye solution discharged at 44 feet to 36 feet, the salt water showing three distinct layers of different salinity, no color appeared on the surface.

Q. Do the experimental studies on the effect of salinity and the direction of discharge on the ascent of fresh water dye solutions in salt water enable you to state what will happen when fresh water is discharged upward and reaches the surface?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. In general it may be stated that in all cases in which the dye solution rose to the surface that the tendency of the fresh water was to come to the surface in an ever enlarging column from the orifice. Then a very slow diffusion downward began. In two hours it moved only a few inches in the downward direction. When it came to the surface after downward discharge in the lower layers it did so in an irregular shaped mass, approaching the shape of the cylinder. Except for the restraining walls of the containing vessel, it would have spread over a larger surface, for there is no reason why it should not move horizontally as well as in a vertical direction downward.

4166 Q. Have you made any other study to show what would be the effect of discharging a large mass of sewage into salt water such as proposed by the Passaic Valley Sewerage Commissioners?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I have made experimental studies on the aeration of water from the atmosphere to show what would be the effect of sewage pollution on such aeration, and I have a report of that series of studies entitled "The aeration of water," with a special topic "The influence of sewage pollution." This report contain- first a photograph of the apparatus that was used for the studies, which consist- of two large elliptical tanks built one over the other, and containing each over 3,000 gallons of water. The object of the two tanks was to enable us to have two waters under exactly the same atmospheric

conditions and I wanted to get as large a volume of water as was possible, and that accounts for the size of the tanks. The report also gives a diagram of the tanks, with a drawing showing the apparatus devised for maintaining the water in motion. Each tank was provided with a wing with shutters which opened and shut so that at a forward movement, the water was pushed ahead in a backward movement the shutters were opened and the water was not moved in the backward direction. The report describes the method of operation for filling the tanks with water, and for boiling the water to drive off the oxygen; we had especially constructed steam connections with the tanks to boil the water. The report also states that the sewage was used from the sewers and that was collected by myself. The report also shows the methods used for examining the amount of dissolved oxygen and gives a description of the reagents that were used. It gives an outline of the plant of observation. First, a study of salt and fresh quiescent waters; second a study of polluted and unpolluted quiescent salt water with varying degrees of pollution; Third, a study of polluted and unpolluted moving salt
4167 water with varying degrees of pollution. A series of observations were made for each one of these outlines, and at the same time that oxygen determinations were made, measurements of humidity, barometer measurements, the temperature of the air and the temperature of the water were made, and the report includes the tables showing the figures as well as the time of day and the day of the week at which the work was done; and in the case of the salt waters showing the salinity of the water, and in the case of polluted waters giving the dilution of sewage in the water. The report also contains some diagrams or curves showing the amount of oxygen contents at the various periods of sampling the water. The report shows the conclusions from each series of determinations, and the conclusions are summarized at the beginning of the report rather than at the close.

Q. Who did the experimental work, and made the experimental studies that are embodied in that report?

A. The experimental work was all done under my immediate supervision and direction.

Q. Who prepared the report?

A. I did.

Mr. O'Sullivan: I offer that report, described by this witness in evidence, and ask that it be marked Complainants exhibit No. 217.

Mr. Riker: I want to ask some questions on that.

Cross-examination by Mr. Riker:

Q. Who did the actual experimental work, Professor Ellery?

A. The actual experimental work was done by my assistant, Mr. A. J. Salathe.

Q. Where is he?

A. In Schenectady.

Q. Not sick, is he?

A. That I cannot answer, sir.

Q. You don't know anything about him now?
A. Not now.
Q. When did you last see him?
A. I think about 10 days ago.
Q. Do you know anything about the truth or falsity of the statements that he has furnished to you as the result of his experiments of your own knowledge?
A. I know they are true.
4168 Q. How do you know they are true?
A. Because I was present when he did his work, and made his calculations.
Q. All of it?
A. Yes sir.
Q. Then it is your work, isn't it?
A. No sir.
Q. You checked it all up?
A. Yes sir.
Q. You took part in the experiments?
A. I was present when they were being done.
Q. Did you watch him while he was making the experiments?
A. Yes sir.
Q. Then you know of your own knowledge that they are correct, do you?
A. Yes sir.
Q. Did you write out this report (indicating)?
A. Yes sir.
Q. How does it differ from the testimony that you are reading from your typewritten copy that you have before you?
A. It does not differ at all.

Mr. Riker: I object to it, on the ground that it is not properly proved, it is not evidence, not rebuttal, and is immaterial, and irrelevant.

The Commissioner: Note the objection of Counsel for the Defendants.

Received in evidence and marked Complainants exhibit No. 216.

Direct examination by Mr. O'Sullivan (resumed):

Q. Will you state what conclusions your experimental studies as embodied in Complainants exhibit No. 217 relating to the influence of pollution on aeration enabled you to reach?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. 1. The rate of absorption of oxygen from the atmosphere by quiescent or slowly moving water seems to be about the same for fresh water as for salt. Whatever effects the rate of absorption seems to effect both fresh and salt water alike.

2. The humidity of the atmosphere affects the rate of ab-
4169 sorption, the greater the humidity, the less the absorption. Hence the most favorable condition for the aeration of water from the atmosphere will be a low percentage of humidity.

3. Under these favorable conditions, a permissible dilution of sewage in quiescent or slowly moving water, water moving less than 1 foot per second, is 1 to 100, that is 1 gallon of sewage to 100 gallons of water, while a dilution of 1 to 60 is not permissible. That is to say, a dilution of 1 to 60 will reduce the oxygen content, while a dilution of 1 to 100 does not materially reduce the oxygen content.

Q. Will you apply these conditions to the conditions found in the vicinity of Robbins Reef Light?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Under the Passaic Valley Sewerage Commission's proposed plan the sewage is to be delivered in an upward direction, as I understand the plan, from 150 openings at a depth of 40 feet or more. With that direction of discharge, it will rise to the surface under the conditions of salinity shown to exist at that point. With the low maximum and minimum and mean current velocities at flood tide which Mr. Johnson testified to, this sewage would require a dilution in the proportion of 1 to 100, whether it were to mix with salty or fresh water, if the oxygen content of the water were not to be reduced, and further, if the water were unpolluted and contained at least 70% of the saturation value of oxygen. If the maximum flow of sewage in the proposed plan is to be 360,000,000 gallons per day, it would have to mix with 36,000,000,000 gallons of unpolluted water to secure the proper dilution, or approximately 4,800,000,000 cubic feet. If the sewage mixed with this quantity of water came to the surface in the shape of a perfect cone with apex at the orifice of discharge 40 feet below the surface, the area covered at the surface would have a diameter of approximately 4 miles.

4170 But the sewage won't come to the surface in the shape of a perfect cone, owing to the resistence of the water and to the interference with each other of the discharges from the different jets. It is more likely to come to the surface directly over the orifice and then spread out over the surface in a layer of increasing thickness, depending on the rapidity of diffusion in a downward direction, a diffusion which is very slow. If the layer is 10 feet thick, its area at the surface would have a diameter of 4.6 miles, if the sewage is to have the proper dilution; if the layer is 20 feet thick the surface area would have a diameter of 2.8 miles.

Of course it is understood that all this 360,000,000 gallons of sewage is not coming out at once, but is the maximum discharge for the day. If one-fourth were discharged every tidal period, the diameter of these surface areas would be divided by four for every such period. But it is to be remembered that this water into which it is proposed to discharge this amount of sewage is already carrying its burdens of sewage, and is never completely refreshed. Only 20 per cent of the water coming in at the Narrows can have a refreshing action, the other 80 per cent being water that has already been in the Harbor and is polluted. That means that in these waters a dilution of 1 gallon of sewage to 500 gallons of water is the permissible limit, or in other words, that the surface area over which the sewage is to be spread if it is to be properly diluted will be five

times as large. If the smallest of these areas is taken, namely that of 2.8 mile, or 0.7 mile per tidal period, that means the sewage discharged in such a period and coming to the surface must move on the surface before its diffusion 3.5 miles in six hours. My belief and opinion is that it wont have sufficient velocity to move that distance in the time, but rather it will remain in a mass near the point of discharge on the surface, or be carried in a mass by the tidal currents oscillating back and forth in the Harbor. In the light of these facts, it seems to me that the introduction of 360,000,-
4171 000 gallons of sewage into the already polluted waters of the Upper Bay of New York will produce an intolerable nuisance condition, resulting from a further depletion of the already reduced oxygen content of the waters of the Bay.

Mr. O'Sullivan: He is your witness, Mr. Riker.

Cross-examination by Mr. Riker:

Q. Professor, you spoke of the proposed discharge of the Passaic Valley Sewer. Where did you get your information as to the proposed discharge of the Passaic Valley Sewer?

(Witness examines papers.)

Q. Can't you answer that without looking at your notes?

A. I am going to tell you exactly where it is; I am looking over Mr. Johnson's testimony.

Q. Well, is it from Mr. Johnson's testimony you got your information?

A. Yes sir.

Q. Have you examined Complainants' exhibit No. 135 which I hand to you (handing witness paper)?

A. I looked this over about two years ago.

Q. Well, look it over again. Do you recognize that as containing a statement of the proposed discharge?

A. I don't put my eye on it here.

Q. Well, take the time to read it through then, and get your eye on it, and see if you recognize that as the proposed discharge of the Passaic Valley Sewer?

A. I read here on page 3 that there will be a series of not less than 150 Tees of a diameter not exceeding 1 foot, and spaces approximately 10 feet apart.

Q. My question is whether you recognize that as the description of the proposed Passaic Valley Sewer?

A. I can't answer that question, Mr. Riker.

Q. Does that describe the discharge upon which you are testifying as the proposed discharge of the Passaic Valley Sewer?

A. I can't answer that.

Q. Why can't you answer that?

A. Because I am not an engineer. I am a chemist, and I am basing my present testimony on a statement contained in the
4172 testimony given by Mr. George A. Johnson with reference to the discharge.

Q. You used the words, however, in your testimony, that the proposed discharge of the Passaic Valley Sewer would have certain definite results?

A. That is a quotation from Mr. Johnson's testimony.

Q. You are quite sure about that, are you?

A. I will read it to you.

Q. I don't want you to read the quotation. My recollection is that you testified on your own evidence that the proposed discharge would have certain results upon the oxygen of the water?

A. In his testimony——

Q. Well, did you or did you not testify, or don't you know whether you testified to that effect?

A. I testified about the proposed discharge, but the words "proposed discharge" are quoted from Mr. Johnson's testimony.

Q. Then you are not testifying of your own knowledge as to the proposed discharge of the Passaic Valley Sewer?

A. I am testifying from Mr. Johnson's testimony.

Q. Is that all you are testifying from?

A. I am taking from Mr. Johnson's testimony, and testifying from that.

Q. Is that all you are testifying from as to the proposed discharge of the Passaic Valley Sewer?

A. In the present instance, yes.

Q. Well, now, what is your business?

A. I am a chemist.

Q. A scientific gentleman?

A. I am a chemist.

Q. A scientific gentleman, are you?

A. I am a chemist.

Q. Are you in the habit of neglecting important data in your work as a chemist?

A. If Mr. Johnson's data are unimportant, then I am.

Q. When you attempt to testify as to the results of the proposed discharge of sewage, do you mean to say that you do not even examine the statement of what is proposed to be done?

A. It seems to me that Mr. Johnson's testimony is sufficient.

Q. Is a sufficient statement of the proposed discharge in your opinion, is it?

A. He is a reputable engineer, and one of your own witnesses.

4173 Q. I draw your attention to Complainants' exhibit No. 135, which was put in on behalf of the people who are retaining and paying you, purporting to be a stipulation between the United States of America and the State of New Jersey, and the Passaic Valley Sewerage Commissioners, stating what will be the results of the discharge of this sewer at Robbins Reef. Have you examined it?

A. I read that over, several years ago.

Q. Would you recognize that as a statement of the proposed discharge, or wouldn't you?

A. I recognize that this stipulation or contract gives an agreement between the United States and the Passaic Valley Sewerage Commissioners as to the character of the material discharged at the orifice at Robbins Reef.

Q. Does that differ in any way from stating that that is a statement of the proposed discharge from the Passaic Valley Sewer?

A. I want to make it very clear what I am testifying to today is from statements made by Mr. Johnson in his testimony.

Q. What I want to have made very clear is whether you identify those statements with Complainants' exhibit No. 135 as the proposed discharge of sewage?

A. That, Mr. Riker, it seems to me to be entirely outside my testimony. If Mr. Johnson's testimony is incorrect, if it does not agree with the stipulation made by the United States with the Passaic Valley Sewerage Commission, then that is Mr. Johnson's error, and he is one of your witnesses.

Q. You are not making an argument?

A. It is not my error at all. I was called upon to make answer to certain statements made by Mr. Johnson in his testimony. I have done so.

Q. Do you recognize the statement of the proposed discharge as given by Mr. Johnson to differ in any respect with the statement made in Complainants' exhibit No. 135?

A. I am not engineer enough to answer that question.

Q. But you are engineer enough to know as to the results
4174 of the discharge as described by Mr. Johnson, are you?

A. I am chemist enough.

Q. You are chemist enough?

A. To know what will happen in a discharge as described by Mr. Johnson of 360,000,000 gallons of sewage per day into salt water.

Q. What was that sewage that Mr. Johnson described to be discharged?

A. He stated that the maximum discharge was 360,000,000 gallons a day.

Q. What kind of sewage?

A. He doesn't state.

Q. Does it make any difference what kind of sewage was to be discharged?

A. If the sewage had been oxidized before being discharged it certainly would make a good deal of difference in the effect on the oxygen content of the water.

Q. It would make a great difference whether it was crude sewage or treated sewage, wouldn't it?

A. Yes sir, on the effect of it on the oxygen content of the water.

Q. Now, which was Mr. Johnson testifying to?

A. Mr. Johnson states that the discharge will be 360,000,000 gallons sewage per day.

Q. What kind of sewage did he say it would be, treated, or untreated?

A. He does not state.

Q. You are sure of that?

A. In that place I am quoting.

Q. In that sentence you are quoting he does not state it?

A. In that testimony with reference to the discharge he does not state.

Q. Have you read all Mr. Johnson's testimony?

A. I think I have.

Q. Don't you know that he testified directly upon Complainants' exhibit No. 135?

A. I do not.

Q. Now, you said that you understood that the discharge would be vertical. Where did you get that understanding from?

A. That I got from my understanding of this contract, and from my various talks with engineers who are conversant with the proposed plan.

Q. You say you get it from this contract, do you?

A. That is my impression, but it has been two years since I read that, and I am not enough of an engineer, as I say, to in-
4175 terpret it anyway; but there are other engineers who are reputable and whom I can quote who have so described that discharge.

Q. I will read to you from the stipulation, at the end of the main paragraph, paragraph first, of the stipulation. (Reading) "On each of these vertical tees shall be placed outlets arranged to discharge horizontally across the tidal current." Do you understand horizontally to mean vertically?

A. No sir.

Q. Well, then if that is the proposed discharge, you are in error in your testimony, aren't you?

A. Not altogether, not sir.

Q. Why aren't you?

A. Because a sewage discharged downward will produce quite a different effect from sewage discharged horizontally or upward.

Q. But when you say that you understand that the sewage is to be discharged upward you are mistaken, aren't you?

A. Yes, I am mistaken with reference to that.

Q. Well, why did you testify on a matter of some importance without having found out what the proposed discharge was to be?

A. I am testifying on the authority of reputable engineers who know the plan.

Q. You had this stipulation before you at one time, did you not?

A. Several years ago, but not as an engineer, Mr. Riker.

Q. I asked you whether you had it before you?

A. Two years ago.

Q. And you knew it contained a contract stating the proposed discharge, did you not?

A. Yes.

Q. Why didn't you refresh your memory when you undertook to testify as to what the proposed discharge was?

A. Because the experiment of your witness, Mr. Johnson, discharged the sewage downward and the effect of discharging sewage

downward is quite different from discharging it in other directions. It makes very little difference if the sewage is not to be discharged downward; it makes a good deal of difference when you are drawing a conclusion from the effect of discharging sewage down-
4176 ward as to what will be the effect when the sewage is discharged in any other direction.

Q. But what I want to know is, when you undertook to state the proposed plan of the Passaic Valley Sewerage Commissioners, why you did not refer to the authoritative statements of it contained in this stipulation?

A. Your witness is an authority and I did not think it was necessary to go any farther than the statements of your witness.

Q. You mean to say our witness Mr. Johnson says that this discharge is vertical?

A. I did not.

Q. Well, I am asking you why when you undertook to testify as to the proposed direction of discharge you did not consult the authoritative document which is put in by your own counsel?

A. What I have done is to take the statement of reputable engineers with reference to that discharge. My impression has been from these reputable engineers that that discharge was not to take place in a downward direction. Your witness made an experiment discharging that sewage in a downward direction; my argument is that what takes place when sewage is discharged in a downward direction is not a criterion of what will take place when it is discharged in any other direction.

Q. Yes, but confine your attention to the part of your testimony where you say you understand the discharge is to be vertical?

A. Yes.

Q. Now, what reputable engineers told you that that was to be the discharge?

A. Well, I got that from several.

Q. Well, who are they?

A. Professor Olin H. Landreth of Union College; another is Professor Phelps of the Massachusetts Institute of Technology.

Q. Who else?

A. I don't recall any others just now.

Q. And they told you that the discharge was to be vertical, did they?

A. As I recall it, yes sir.

Q. You recognize that the proposed discharge is not to be vertical, do you not?

(Counsel hands witness Complainants' exhibit No. 135.)

A. I note that it states in this stipulation that the dis-
4177 charge is to be horizontally across the tidal current.

Q. Have you any doubt as to that being what is proposed to be done?

A. No sir.

Q. Then, you are mistaken in your understanding, are you not?

A. I am mistaken in my understanding as to the direction of

discharge; I am not mistaken in my understanding as to what will take place when sewage is discharged downward, and as to what will take place when it is discharged in any other direction.

Q. I did not ask you that; I asked you whether you are mistaken as to the direction of the discharge proposed?

A. I answered yes.

Q. Now, the dye experiments conducted by Mr. Johnson, to which you have directed your testimony at length consisted of the use of what dye?

A. What he called Red R dye.

Q. Have you any doubt that he calls it correctly?

A. I have.

Q. What should it be called, in your opinion?

A. — Red R dye.

Q. Why?

A. Because there is not any Red R dye on the market.

Q. Then, if there is another Red R dye in the market, you think the addition of 2 makes any difference?

A. Makes a great deal of difference.

Q. Then you think he used 2R, do you, instead of one R?

A. I think so.

Q. Do you know?

A. I don't know anything about it.

Q. Do you doubt it?

A. I know he did not use Red R dye.

Q. Do you doubt that he used R dye?

A. I have not any knowledge.

Q. I asked you whether you knew?

A. I have no knowledge, sir.

Q. Do you doubt that the results of the experiment as described by him were correctly observed?

A. Not at all.

Q. And that he did not find traces of the Red R dye on the surface?

A. Not at all.

Q. And that there were in fact no indications of the Red R dye in the water?

4178 A. I don't doubt that testimony at all.

Q. You don't doubt that his observations were correctly made and correctly represent the facts, do you?

A. I don't doubt that at all.

Q. How does the solution of the Red R dye in the proportions that he describes compare, so far as its visibility is concerned, with the proposed discharge from the Passaic Valley Sewer?

A. It might have come to the surface, and being so weak a solution the color would not be visible to him. A solution of that dye, 1 to 12,000, is a very thin solution.

Q. Taking and comparing it with the proposed discharge from the Passaic Valley sewer before it is diffused in any water which would be more marked and striking?

A. What are you comparing, Mr. Riker?

Q. I am comparing the solution of the Red R dye which you describe with the sewage as you understand it is proposed to be discharged at Robbins Reef from the Passaic Valley Sewer?

A. I think you cannot make any inference whatever from his experiment, because he delivered his dye down rather than in a sidewise direction or up.

Q. Will you make a comparison of the two as you understand them, the Red R dye solution, and the sewage as discharged at Robbins Reef?

A. I cannot make any comparisons.

Q. Why not?

A. Because the direction of the discharge is not the same.

Q. Take it before it is discharged: I want you to take the two things and compare them, that is what I am asking you to do. Which is the more visible and more marked, the more striking, the Red R solution or the sewage?

A. In the strength of solution that Mr. Johnson used, I do not know that you could say that the dye solution would be more marked than the sewage solution. It is a very weak solution, Mr. Riker.

Q. Well, what is the sewage with which you are comparing it?

A. That is colorless, practically colorless; it is not a dyed color at all.

Q. You think it differs from pure clear water in as marked
4179 a degree as the Red R dye solution, do you?

A. In that strength of solution, I should think it would be perhaps a little less marked than the Red R dye solution as Mr. Johnson calls it. At the same time, when you deliver the Red R dye solution, as he calls it, into that salt water there, by the time it has come to the surface, I think the solution would become so thin as not to be visible.

Q. Now, I want to know what the character of the sewage is that you are comparing in your mind the Red R dye solution with?

A. Sewage as I have seen it running through sewers.

Q. Untreated?

A. Untreated.

Q. You are not comparing it with sewage that has been treated in any way?

A. No.

Q. You are not comparing it with an effluent which will produce the results which are guaranteed in Complainants' exhibit No. 135?

A. No, I think not.

Q. Well, don't you know whether you are or not?

A. Yes, I think I know: I think I am not comparing it with any sewage treated as this stipulation proposes this sewage shall be treated before discharged. I don't know that I have ever seen any sewage with such treatment in the way this stipulation suggests this sewage shall be treated. I think I never have, so I could not compare it with that.

Q. So that your comparison now is with sewage different from that which it is proposed to discharge into New York Bay?

A. If the treatment gives a different color, yes.

Q. Well, if the results which are guaranteed in this stipulation are attained, won't the sewage be of a different color?

A. That I cannot answer.

Q. Cannot even express any opinion on it?

A. I would rather not.

Q. Why would yo- rather not?

A. I am not a sewage expert.

Q. It takes a sewage expert to know that, does it?

A. More of a sewage expert than I am.

4180 Q. Well, I draw your attention to one of the results which is guaranteed from the effluent, that there will be absence in New York Bay of visible suspended particles coming from the Passaic Valley. Do you need to be a sewage expert to know that will be an effluent which will be different in its visible character from the sewage with which you are comparing the Red B. dye solution?

A. I have seen some sewage untreated that had no visible suspended particles.

Q. Well, I draw your attention to another guaranteed result, there will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area. Would that have any effect on your view as to the appearance of the sewage or the effluent when discharged?

A. I will answer that in the same way that I did your other question: I have seen some sewage that had no grease or oily substances in it.

Q. Is that the kind of sewage you are comparing the Red dye solution with?

A. That is the kind of sewage I have in mind, yes sir.

Q. That is the kind?

A. Yes.

Q. And you think the red dye solution will be very little less different from clear water than that kind of sewage?

A. I think the effect of discharging it in the water would be about the same.

Q. Won't you answer my question, Professor?

A. I have.

The stenographer read the question, as follows:

"Q. And you think the Red dye solution will be very little less different from the clear water than that kind of sewage?"

Q. Now, will you answer it?

By direction, the stenographer read the answer, as follows:

"A. I think the effect of discharging it in the water would be about the same."

The Witness: That is my answer, Mr. Riker.

Q. I am asking you not as to the effect, but I am asking
4181 you as to the thing itself; looking at the two, do you mean to say the red dye solution will be little less marked than the sewage which you are now describing?

A. If you should take a pail of your red dye solution, and a pail of the sewage that I have in mind you would see a difference. If you should take that pail of red dye solution and discharge it into salt water, and take a pail of sewage that I have in mind, and discharge it into salt water, I think the effect would not be greatly different.

Q. And if you should take the pail of uranine and discharge it into salt water, at a depth of 40 feet, and a pail of the sewage, would the effect upon the surface be very different?

A. Very.

Q. You think you would see the effect of the uranine discharged at 40 feet?

A. Yes sir, if it came to the surface, you certainly would.

Q. Well, do you think it would come to the surface?

A. All depends on salinity of your water at different depths; depends upon the direction of discharge and depends upon the velocity of the discharge.

Q. Professor, you said that this discharge of 360 million gallons of sewage per day at Robbins Reef as proposed would produce an intolerable nuisance?

A. That is my opinion and belief.

Q. What is the proposed discharge that you have in mind when you testify that that would be the result?

A. I was testifying there to a maximum discharge of 360,000,000 gallons per day.

Q. Of what?

A. Of sewage.

Q. What kind of sewage?

A. Ordinary sewage.

Q. Untreated?

A. Untreated.

Q. What would be the result in your opinion of the discharge of 360,000,000 gallons of sewage, treated as stipulated and declared and proposed in Complainants exhibit No. 135?

A. I don't know what the effect of the treatment would be upon that sewage, I must make that very clear, because I am not a sewage expert and have never seen sewage that has been treated like that.

All I can answer to that is that if you are going to discharge
4182 into the waters of the Bay sewage so treated that there will be no reduction of the oxygen conten' of the water; that is to say, if you are going to discharge practically a fresh water out there, then, Mr. Riker, I cannot see why you should discharge it there at all.

Q. Do you see why that is any of your business?

A. I don't see any reason in the world why you should not discharge it into Newark Bay.

Q. Do you see why that is any of your business?

A. Why, surely.

Q. Why?

A. Well, I won't answer that question.

Q. Well, if the effluent as produced results in the results guaranteed in Complainants' exhibit No. 135, do you think there will be an intolerable nuisance created in New York Harbor?

A. If you are discharging a fresh water with its organic matter entirely oxidized there will not be an intolerable nuisance in New York Harbor.

Q. Is that your answer?

A. That is my answer.

Q. Do you understand that the effluent as described in Complainants exhibit No. 135 will be a fresh water discharge as described by you?

A. That is my idea of fresh water, yes. You are discharging there a water free from visible suspended particles.

Q. Does it say so?

A. Yes.

Q. Read it?

A. (Reading:) "There will be an absence in New York Bay of visible suspended particles coming from the Passaic Valley sewage."

Q. Do you mean to say that that is equivalent to an effluent in which there are no visible suspended particles, in your opinion?

A. That is what it states here, that there will be an absence in New York Bay of visible suspended particles.

Q. Do you mean to say that that is equivalent, in your opinion to an effluent in which there are no visible suspended particles?

A. That is what it states here, Mr. Riker.

4183 Q. All right, that is your answer?

A. You say further, (reading) "There will be an absence of deposits objectionable to the Secretary of War," and you say further "there will be an absence in New York Bay and its vicinity of odors due to the putrefaction of organic matter." That must mean that the organic matter will be oxidized before it gets out there. "There will be a practical absence on the surface of any grease or color due to the discharge." That must mean that it is all removed before it gets there. "There will be no injury to the public health which will be occasioned by the discharge from the said sewer and no public or private nuisance will be created thereby." That must mean you have removed your organic matter completely and anything that would cause disease. "Absence of injurious effects from said sewage discharge upon the property of the United States." That might mean a good many things, I suppose. If it has reference to the discharge of gases, that means that the material in the water has been oxidized. "There will be absence in the reduction of dissolved oxygen in New York Bay resulting from the discharge of Passaic Valley Sewage." That must mean——

Q. Read it all?

A. (Reading:) "To such an extent as to interfere with major

fish life." That must mean that the organic content has been oxidized. Now, that is what I am describing as fresh water.

Q. What is the amount of reduction in the dissolved oxygen which will injuriously affect major fish life?

A. I cannot answer that.

Q. Then, why do you say that the material must have been oxidized?

A. Because if you have any oxidizable material there, you are going to reduce the oxygen content of the water.

Q. Yes, to the extent of injuriously affecting the major fish life?

A. Yes.

Q. That is the stipulation, isn't it?

A. Yes.

Q. What is the amount of reduction which will injuri-
4184 ously affect major fish life?

A. That I cannot answer.

Q. Then how can you testify as to a reduction of the dissolved oxygen?

A. Because if you have any oxidizable material, you are going to reduce the oxygen content.

Q. To an extent that will injuriously affect major fish life?

A. You are going to reduce the oxygen content.

Q. The stipulation limits it to injurious effect on major fish life; do you mean to say it is necessary to have sewer water in order to attain that result?

A. I don't know that.

Q. Then, why do you testify to that?

A. I am testifying just exactly as my answers have indicated.

Q. Don't you understand that the effluent as described by its results in the stipulation is the proposed effluent to be discharged?

A. I understand that that is the proposed effluent, yes sir.

Mr. Riker: That is all, Professor.

Redirect examination by Mr. O'Sullivan:

Q. Professor Ellery, the expression has been used in putting questions to you, "proposed discharge"; what do you understand by these two words?

A. Those are terms used by Mr. Johnson, and I have taken them right out of his testimony.

Q. What do you understand by the two words "proposed discharge"; do you understand that to be the method of discharging the sewage or the sewage effluent, or the substance of the sewage, or the sewage effluent itself?

A. From what Mr. Johnson has stated, I understand the
4185 direction of discharge, and the amount of discharge, or volume of discharge.

Q. You mentioned something in relation to the Red R dye. Does Mr. Johnson state in his testimony where he got the Red R dye he testified that he experimented with?

A. He does, from Herman A. Metz & Company.

Q. Did you communicate with Herman A. Metz & Company in relation to that dye?

A. I did.

Q. And what did you find?

A. I find that there is no dye so called on the market, as a Red R dye, at least they have not handled it, do not handle it; and I inquired of several other firms, three or four, and find that they also do not know of any Red R dye.

Q. In what direction were Mr. Johnson's experiments conducted?

A. The discharge was downward.

Q. Does that compare with a horizontal discharge in any way so that you could draw an inference or conclusion?

A. It does not.

Q. What directions did you experiment with in your dye experimentation?

A. In a downward direction, in a lateral or sidewise direction, and in an upward direction.

Q. Vertical horizontal and downward?

A. Yes sir.

Q. I direct your attention, Professor Ellery, to Complainants' exhibit No. 135, and particularly to page 3 of that exhibit, in which the results guaranteed in relation to this sewage effluent are set forth, and ask you if an effluent will correspond with the stipulated or guaranteed results if it would differ materially from the ordinary drinking water?

A. That is my interpretation of that, that it will not; that it will be a fresh, pure water.

Q. Have you had much experience in water analysis?

A. A good deal in water analysis, yes sir.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. Are you a sewage expert.

A. I am not.

4186 Q. How do you undertake to say whether an effluent of this character will be pure water then?

A. From the description that is given of it here.

Q. And when you deal with the proposed discharge, you only deal with the quantity and direction, is that so?

A. I am basing my testimony upon Mr. Johnson's testimony which deals with the quantity and direction of discharge.

Q. I am now examining you upon your re-direct examination Professor Ellery. You were asked what you understood by "proposed discharge" and as I recall it, you said you dealt with the quantity of 360,000,000 gallons a day, and the direction, is that all you dealth with?

A. That is all.

Q. It makes no difference what the quality of the sewage is?

A. As to what?

Q. As to its results?
A. Results on what?
Q. Anything?
A. It makes a lot of difference.

Mr. Riker: That is all.
Mr. O'Sullivan: That is all.

Adjourned to June 26th, 1913 at 10:30 A. M.

4187 Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, June 26th, 1913—10:30 a. m.

Before James D. Maher, Commissioner.

Appearances:

William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants;
Adrian S. Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

Met pursuant to adjournment.

RUDOLPH HERING, a witness called in behalf of the Complainants, in rebuttal, being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Mr. Hering?
A. Rudolph Hering.
Q. What is your profession?
A. Civil engineer and hydraulic engineer.
Q. Where are you now pursuing your profession?
A. My office is in New York, 170 Broadway.
Q. Are you practicing alone, or are you part of a firm?
A. I am part of a firm, Hering & Gregory.
Q. And previous to that, were you in any partnership?
A. Previous to that I was in the firm of Hering and Fuller,
4188 same office.
Q. Where did you study civil engineering; state where and when?
A. I went to Germany, when I was in my fourteenth year, and went to a preparatory school in Dresden, and later to the Technical High School there, which is the name of the highest institution of learning for engineers.

Q. In what city?

A. In Dresden. I returned home in 1867.

Q. After completing your studies?

A. Yes sir.

Q. And what were you engaged in then in the line of your profession?

A. My first position was in Brooklyn, at Prospect Park, and then at Philadelphia Park.

Q. In what years at Prospect Park?

A. 1868 and 1869 to 1871 in Philadelphia Park. In 1872 I joined the United States Government Geological Survey for exploration in the Rocky Mountains, Yellowstone Park. After that I was assistant engineer in the City of Philadelphia, in charge of the building of bridges and sewers.

Q. Any particular bridge?

A. The first bridge was the Girard Avenue bridge, which crosses the Schuylkill River, in Fairmount Park. I was the resident engineer there from morning until night for a year and a half, until the completion of the work; and then I was engineer,—although not on the work continously—for other bridges on the Schuylkill River, Fairmount and others, and smaller ones.

I was born in Philadelphia in 1847, and studied civil engineering in Dresden, Germany, from 1860 to 1867. I was engaged in Prospect Park, Brooklyn, New York, from 1868 to 1869; on Fairmount Park, Philadelphia, from 1869 to 1871; on Yellowstone Park Exploration in 1872; was resident engineer on Girard Avenue Bridge, Philadelphia during the entire time of its construction, 1873 to 1875; and Assistant City Engineer of Philadelphia in charge of sewers, from 1876 to 1880.

In 1880, I was engaged by the National Board of Health to report on the sewerage works of Europe. This report was published in 1881.

Since 1882 in private practice. From 1901 to 1911 I was a member of the firm of Hering & Fuller. From 1911 to date I
4189 have been a member of the firm of Hering & Gregory.

Since 1881 I have examined and studied the best works of water supply, sewerage, sewage purification and refuse disposal in Europe, during seven visits for that purpose.

In 1907, I received Honorary Degree of Doctor of Science from the University of Pennsylvania.

The following are the principal professional engagements:

Philadelphia, Pa. Surveys and investigations for a new water supply from 1883 to 1886.

Chicago, Ill. Chief Enginer of the Water Supply and Drainage Commission, from 1886 to 1888.

Reports, plans and recommendations for the new water supplies or their extensions, for the following cities:

Atlanta, Ga. in 1890.

Plainfield, N. J., in 1890.

Dallas, Texas Reservoir, in 1891.

Buffalo, N. Y., Reservoir, in 1891 and 1892.

Tacoma, Washington, in 1892.
Colorado Springs, Colorado, in 1893.
Philadelphia, Pa. W. Queen Lane Reservoir in 1896.
Philadelphia, Pa. in 1897 (Schuylkill River, Private Company).
Honolulu, H. I., in 1897.
Winnepeg, Manitoba, in 1897.
Hartford, Conn. in 1898.
Princeton, New Jersey, in 1898.
Sacramento, Cal., in 1900.
Sault Ste. Marie, Mich., in 1901.
Meadville, Pa., in 1901-1904.
San Francisco, Cal., 1903-1905.

4190 Toronto, Ont., Consulting Engineer with S. A. Gray on investigations for a new water supply in 1884.

Santos, Brazil. Consulting Engineer with Prof. E. S. Fuertes and J. H. Fuertes, making design for a new water supply in 1893.

Cleveland, Ohio. Consulting Engineer with George H. Benzenberg, and Desmond Fitz Gerald, recommending improvements for the water supply in 1895.

Philadelphia, Pa., Consulting Engineer with Messrs. S. M. Gray and J. M. Wilson recommending the filtration of the water supply in 1899.

Buffalo, N. Y., Consulting Engineer with Col. Symons and Gen. Field, recommending the new water works intake and other supply improvements in 1899.

Washington, D. C., Consulting Engineer with G. W. Fuller and Allen Hazen, recommending filtration of the water supply in 1900.

New York. Member of Commission with Wm. H. Burr and John R. Freeman, studying possibilities for additional water supply for the City of New York, and recommending the Catskill supply in 1903.

Pittsburgh, Pa., Consulting Engineer with Col. A. M. Miller, U. S. A., and John W. Hill, recommending the filtration of the water supply in 1904.

Acted as Consulting Engineer with George W. Fuller on the water supplies for

New Orleans, La., in 1901. Minneapolis, Minn., in 1910.
Columbus, O., in 1901-1905. Montreal P. Q., Can. in 1910.

Valuations of water supply properties in ten cities, some for the cities, some for private companies.

Acted as expert witness on numerous law cases relating to matters of water supply.

Reports, designs and construction of sewerage systems for the following cities:

4191 Waterbury, Conn., in 1882.
Roanoke, Va., in 1882.
Binghampton, N. Y., in 1882 to 1889.
Duluth, Minn., in 1884 to 1890.
Trenton, N. J., in 1884-1889.
New London, Conn., in 1887-1892.
Montgomery, Ala., in 1888-1891.

Atlanta, Ga., in 1888 to date.
Superior, Wis., in 1891.
Ithaca, N. Y., in 1896.
Honolulu, H. I., 1896-1899.
Batavia, N. Y., in 1909.

Reports, plans and recommendations for systems of sewerage for the following cities:

Cleveland, Ohio, in 1882.
Wilmington, Delaware, in 1883.
Petersburg, Va., in 1884.
Lynn, Mass., in 1884.
Altoona, Pa., in 1884 & 1885.
Pasadena, Cal., in 1887.
Los Angeles, Cal., in 1887 to 1890.
Wichita, Kansas, 1888.
St. Johns, N. F., in 1889 to 1891.
Ogden, Utah, in 1890.
Savannah, Ga., in 1890.
Oakland, Cal., in 1890.
Springfield, Mass., in 1891.
Wilmington, N. C., in 1891.
East Portland, Ore., in 1891.
4192 Roanoke, Va., in 1891.
Indianapolis, Ind., in 1892.
Sioux Falls, S. D., in 1892.
Woonsocket, R. I., in 1892 and 1895.
Hartford, Conn. in 1893.
Charlottesville, Va., in 1894.
Ithaca, N. Y., in 1894.
Portland, Me., in 1894.
Waterbury, Conn., in 1896.
Ottawa, Ont., on 1897.
So. Bethlehem, Pa., in 1897.
Saulte Ste. Marie, Mich., in 1901.
Sacramento, Cal., in 1901.
Chicago Sanitary District, Calumet Sewerage, in 1907.
Bridgeport, Conn., 1907-1908.

Providence, R. I. Consulting Engineer for the Improved Sewerage system in 1883-1887.

Boston, Mass., Consulting Engineer with J. P. Davis on Main Drainage in 1885.

Chicago, Ill. Chief Engineer of the Water Supply and Drainage Commission, recommending the drainage canal as now built for the disposition of sewage of the City, 1886 to 1888.

New York City, N. Y. Consulting Engineer from 1887 to 1889 to the Board of Public Works, on its sewerage system.

Toronto, Ont. Consulting Engineer with S. M. Gray on a sewage disposal system in 1888.

St. Johns, Newfoundland. Consulting Engineer recommending system of sewage and disposal in 1889.

Washington, D. C. Consulting Engineer with S. M. Gray and

F. P. Stearns, recommending design for the sewerage system, in 1890 and 1893.

4193 Newton, Mass. Consulting engineer for the improved sewerage system in 1891-1893.

Victoria, B. C. Consulting Engineer recommending system of sewerage and sewage disposal in 1890.

New Orleans, La., Consulting Engineer with Major Harrod and Major Richardson on the general construction of the sewerage and drainage systems from 1892 to 1907.

Santos, Brazil, Consulting Engineer with Prof. E. A. Fuertes and Jas. H. Fuertes, designing a system of sewerage in 1893 and 1894.

Baltimore, Md., Consulting Engineer with S. M. Gray and F. P. Stearns, recommending design for the sewerage system, in 1895 and 1906.

San Francisco, Ca. Consulting Engineer to Mr. Marston Manson and C. E. Grunsky for the design of a system of sewerage and sewage disposal in 1899.

Columbus, Ohio. Consulting Engineer with George W. Fuller for designing and constructing the sewage disposal works in 1901.

Passaic Valley, N. J., Consulting Engineer on several occasions recommending a system of sewage collection and disposal from 1901 to 1908.

Reading Pa., Consulting Engineer with George W. Fuller for the designing and constructing the sewage disposal works, in 1906.

Rochester, N. Y., Consulting Engineer with George H. Benzenberg on the sewage disposal works in 1907.

Toronto, Ont., Consulting Engineer with J. D. Watson, England on a sewage disposal system in 1910.

Acted as expert witness on numerous law cases relating to sewage matters.

American Public Health Association. Chairman Committee on Refuse Disposal from 1895 to 1903. In 1912, Chairman of the Section on Sanitary Engineering of this Association.

4194 New York. Member of Commission with H. De B. Parsons and Samuel Whinery to report on Street Cleaning and Waste Disposal in 1907.

Milwaukee, Wis., Study and report on refuse disposal, and Consulting Engineer during construction of the works in 1907-1909.

Pittsburgh Pa., study and report on refuse disposal in 1908.

San Francisco, Cal., Study and report recommending refuse disposal works in 1909. Now under construction.

Toronto, Ont., Study and report on refuse disposal together with Mr. J. H. Gregory in 1911.

I am also a member of the following scientific Associations:

American Society of Civil Engineers.
Institution of Civil Engineers, Great Britain.
American Society of Mechanical Engineers.
American Institute of Consulting Engineers.
Canadian Society of Civil Engineers.
American Public Health Association.
Boston Society of Civil Engineers.

American Water Works Association.
New England Water Works Association.
Engineers' Club of Philadelphia.
Western Society of Civil Engineers.
Franklin Institute, Philadelphia.
American Academy of Sciences.
Verein Deutcher Ingenieure.

Q. Mr. Hering, have you any official relationship with the American Public Health Association?

A. I am president of the Association, this year.

Q. And previous to that, did you hold a Chairmanship in any of the Sections?

A. Previous to that I was the Chairman of the Sanitary Engineering Section.

Q. Did the Sanitary Engineering Section take into consideration and make the subject of research, air supplies?

4195 A. Yes, sir.

Q. Did they make researches toward determining the physiology and pathology of respiration?

A. That was one of the duties.

Q. Was it part of their functions to determine the variations in the chemical constituents of air?

A. Yes sir.

Q. Variations in physical condition of the air?

A. Yes sir.

Q. The Bacterial and other particular constituents of air?

A. Yes sir.

Q. Did they take into consideration the condition of the atmosphere of unenclosed spaces, and of enclosed spaces?

A. Yes sir.

Q. Did they take into consideration the control of physical and chemical air conditions in enclosed spaces?

A. Yes sir.

Q. And the control of air conditions in enclosed spaces as regards dust bacteria and odors?

A. Yes, sir.

Q. Was it a function of that section to take into consideration the water supplies that would determine the general quality, the bacteria and other constituents, and the hygienic efficiency, of the water?

A. Yes sir.

Q. Did they take as part of their duties the determination of the effects of aeration and sedimentation on the storage of waters and their thermal stratification on the distribution of plankton, dissolved oxygen and other features of water supplies?

A. Yes sir.

Mr. Riker: The question is objected to on the ground that it is not directed to any testimony offered on the part of the defence.

Mr. O'Sullivan: These questions are pressed with a view to showing the qualifications of this witness and the wide scope of his re-

search and professional activities in determining questions that will be later submitted to his direct inquiry.

The Commissioner: Note the objection of Counsel for the Defendants.

Q. Did that Section take into consideration the ground waters, sprinkling filters and the slow sand filtration, the rapid mechanical filtration, with a view to determining their effects upon water
4196 supplies?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes, sir.

Q. Was there a Section of that new division that undertook to determine the pathological and nuisance data in relation to sewage collection and treatment?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir.

Q. Did they take under consideration the pathological changes arising from sewage and the conditions favoring and preventing pathological dangers from sewage?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir.

Q. Did they take into consideration the sewage disposal problems, the pathological and nuisance data, and the pathological dangers and nuisance from air pollution and effluents at the different styles of purification works?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir.

Q. Did they also consider the pathological dangers and nuisances, inherent to the essential features of works for economically purifying sewage?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir. Of course, this is in the present tense that I answer it; that is these questions have not all been answered. Investigations have not all been made but it is the present program for the Section.

Q. Did they take into consideration the oxidizing of liquids
4197 and the danger from pathogenic bacteria in sewage entering bodies of water, and infecting fish and bathers?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir.

Q. Did they take under their consideration the danger from flies and other winged insects which are bred in these sewage filtration and other sewage works?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir.

Q. Mr. Hering, did you make a study of the disposal of the sewage of the Passaic Valley Sewerage District and prepare plans for the discharge of this sewage into Upper New York Bay, and submit these plans along with the report on the subject to the Passaic Valley Sewerage Commissioners dated December 31, 1907?

Mr. Riker: The same objection is raised to this:

That it is not rebuttal of any evidence introduced on the part of the Defendants, and it is merely cumulative evidence of the defence.

The Commissioner: Note the objection of counsel for the defendants.

A. Yes sir, in connection with my partner.

Q. Who was your partner?

A. Mr. George W. Fuller.

Q. I call your attention to page 3990 of the record or minutes made by the stenographer at the hearings in this suit, and ask you to consult your copy of the report made by Hering & Fuller for the Passaic Valley Sewerage Commissioners, dated Dece-ber 31st, 1907, and see if you can find the following quotation from your report therein, as reported on said page 3990 of the stenographic minutes in this case: "The indications are under present conditions that the sewage as it reaches the pumping station on the Newark Meadows will normally be devoid of dissolved oxygen. From the fore-
4198 going result it seems quite plain that even though the discharge from the several outlets contribute considerable dissolved oxygen, this will be quite speedily absorbed. In its travel of 20 miles in some 10 hours, it will become septic, but the more or less constant addition along the route of sewage containing dissolved oxygen will retard rapid putrefaction. As received at the pumping station the sewage will doubtless be septic and blackened." Do you find that quotation as I have read it in your report for December 31, 1907, to the Passaic Valley Sewerage Commission?

A. I do so find it.

Q. Was that report along with your plans adopted by the Passaic Valley Sewerage Commission?

Mr. Riker: The objection is made that this is not rebuttal, whether it was adopted or not, and is not within the knowledge of this witness. The proper way to prove that is from the records of the Commission.

The Commissioner: Note the objection of Counsel for Defendants.

Mr. O'Sullivan: The question is pressed for the reason that Mr. Johnson, a witness called by the defense, denied that any such portion of the report existed, and although he had before him what

purported to be a copy of the report, he refused to let me look for just that portion that I have quoted.

A. I presume it was.

Mr. Riker: I move it be stricken out, as not testimony.

The Commissioner: Note the motion of counsel for the defendants.

Q. Do you know, Mr. Hering, whether any changes of your plans for the proposed Passaic Valley Trunk sewer, and the sewage treatment works, and the long outlet sewer from Newark to the vicinity of Robbins Reef light have been made and adopted by the Passaic Valley Sewerage Commission?

Mr. Riker: The same objection, on the ground that the best proof is the proof by the records of the official body which has
4199 the power to adopt or reject them.

The Commissioner: Note the objection of Counsel for the defendants.

A. I believe some changes have been made, although I do not believe,—and have no information regarding it,—of a material nature.

Q. Have you continued your general study of the conditions in Upper New York Bay and New York Harbor since December 1907?

A. I have.

Q. Have you continued your study of the subject of sewage disposal and the discharge into brackish and sea water, since December, 1907, up to the present time?

A. I have.

Q. Have you studied closely the effect of the discharge into salt water harbors, and estuaries in this country and in Europe, since December, 1907?

A. I have.

Q. Have you studied the various methods of treating large volumes of sewage prior to discharge into brackish and salt water harbors and estuaries and have you formed an opinion in regard to the efficiency of such methods in preventing the development of offensive conditions in such waters?

A. I have.

Q. What will become of the excess of the trade wastes and ground water and storm water that reaches the tributary sewer systems, and is excluded from the proposed trunk sewer and sewage treatment works as now projected by the Passaic Valley Sewerage Commissioners.

Mr. Riker: The question is objected to for the reason that it is not rebuttal of any evidence offered on behalf of the defence.

The Commissioner: Note the objection of counsel for the defendants.

A. That excess of storm water will flow over into the Passaic River.

Q. And now as to trade wastes?

A. The trade wastes also, unless they are retained by the producers of the trade waste, and purified.

4200 Q. Has any provision been made that you know of, for such local treatment by the manufacturing plants of their trade wastes?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I am not aware of it.

Q. Mr. Hering, how will the discharge of this excess of liquid composed of trade wastes, ground water and storm water affect the quality of the Passaic River and of Newark Bay after the completion of the project proposed by the Passaic Valley Sewerage Commissioners?

Mr. Riker: The question is objected to for the reasons already given as to other questions and also on the ground that it is immaterial and irrelevant as to what is discharged into the Passaic River, the question under consideration being the supposed threatened pollution of the waters of Upper New York Bay.

The Commissioner: Note the objection of counsel for the Defendants.

A. It will pollute it to the extent of the polluting material which flows over into the river.

Q. Can you suggest an appropriate way for preventing this fouling of the Passaic River and Newark Bay by these excess polluting liquids?

Mr. Riker: The same objection?

The Commissioner: Note the objection.

A. It was my expectation when connected with the original design of the works that the trade wastes would be kept back, purified, and an effluent satisfactory to the proper authorities discharged into the river. Regarding the overflow of the storm water, excessive flows, it was my expectation that as soon as it would become practicable the two cities connected with the sewer, namely Paterson and Newark, which now have substantially what is known as the combined system of sewers receiving rain water and sewage together, would then have constructed a separate system

4201 whereby storm waters alone, not mixed with sewage, would be discharged into the river, and the sewage alone not mixed with storm water would enter the trunk sewer and be discharged wherever the outfall would be. There was a provision in the act stating that 10 per cent of the trade wastes might be admitted to the sewer. The only use that the engineer could make of this provision was to allow an increased capacity to cover this amount.

Q. Mr. Hering, what will be the character and appearance of the contents of the proposed trunk sewer when it arrives at the proposed sewage treatment works or near the Newark Meadows.

Mr. Riker: The same objection, on the ground that it is not rebuttal.

The Commissioner: Note the objection.

A. Some of the sewage, namely that which arrives from Paterson, the upper limits of the proposed sewer, would be of a different nature from what it is at the lower end, the suspended solid matter would gradually become broken up, large pieces would become small pieces, the dissolvable matter would be taken out by the water, and while there is at the point of discharge from the house a very small amount indeed of dissolved organic matter in the sewage, there would become constantly an increase of such dissolved matter and then at the end of a long flow such as this would be, there would be a very large amount of organic matter dissolved, probably more than half the entire amount. The rest of the organic matter which would be in a solid and colloidal form would be broken up, comminuted, and very difficult to be kept out by straining or screening, and also more difficult to be kept out by sedimentation. The larger particles would settle more rapidly, and more effectually than the fine mostly colloidal matter, most of which requires a long time to settle, and some of which does not settle at all.

Q. Would the sewage be septic?

4202 Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. The sewage becomes septic, when the oxygen in the water has been removed by absorption and combination. The speed of this process depends upon the nature of the organic matter, some of which chiefly animal matter, absorbs oxygen very rapidly. After the oxygen is absorbed which is accomplished in the presence of and what are known as aerobic bacteria, then in the absence of the free oxygen in the water another class of bacteria begins its activity. It draws what it needs for its work from the sewage deprived of its free oxygen, and sets up a new process which we call putrefaction, which is accomplished by the evolution of certain gases, some of which are very offensive in their odors, the chief one being sulphuretted hydrogen. In that condition, we call the sewage septic.

Q. Is septic sewage blackened or any other color?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. Septic sewage generally has a blackish appearance.

Q. Would you expect the sewage coming from Paterson and Passaic blackened and septic when it reached the Newark Meadows of the disposal works?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I should expect the sewage of Paterson and Passaic to be septic by the time it reached the disposal works, although it is mingled with fresh sewage on the way down. I have seen the sewage of Newark, which would enter at the lowest points of the trunk

sewer, in a septic condition, and of course in that case the septic sewage from higher up would not be changed. If the sewage of a large city like Newark could all be discharged into the trunk sewer in a fresh condition, there might be a reduction of the sectic condition in the trunk sewer for a short time, although I
4203 would expect that it would very soon reappear, because the oxygen would be very rapidly absorbed by the peculiar condition of that sewage, and it might be a question of a fraction of an hour, in my opinion, before the entire mass would become septic, although the exact conclusion depends a good deal upon the exact detailed condition of the composite sewage.

Q. Is it a general experience of sanitary engineers to find that septic sewage rapidly infects fresh water?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes, sir, as I have just stated, it accelerates the decomposition, and hastens the putrefaction by the rapid absorption of the remaining oxygen.

Q. How long is it contemplated to detain the sewage in the treatment works and state whether or not the time given is sufficient, in your opinion?

Mr. Riker: The same objection, and the additional objection that the intention of the Commissioners must be properly proved by the production of the records.

The Commissioner: Note the objection of counsel for the defendants.

Mr. O'Sullivan: And before answering the question, Mr. Hering, I will direct your attention to Plaintiffs' exhibit No. 135, which discloses, as far as this suit is concerned the detention period set forth by the Passaic Valley Sewerage Commissioners. (Counsel hands witness stipulation.)

The Witness: According to the document I hold in my hands, being Complainants' exhibit No. 135, giving certain dimensions of detention tanks, it is intended that the tank capacity will always be such as to provide a detention period of not less than one hour at the maximum rate of sewage, and a detention period of the daily average flow of such sewage of not less than one hour and
4204 a half. At the time this document was prepared, certain suggestions were presented to the engineers, myself included. At that time the progress seemed to be making toward the values of such detentions and I felt that the original proposition, which was put before me, was insufficient and as this document was to be an agreement between two states, I was very anxious that the agreement should be in the line of progress. At that time I was not able to fix any definite time of detention to secure definite results. No money was available to make investigations to settle these facts; the conclusions had to be based upon opinions and I remember very well that I materially increased the time of detention from one point of view and materially decreased it from another point of view. When I say increased it from one point of view, I mean from a detention

to keep out merely what we call grit, the heavy material, chiefly silica, which would enter the sewer from the street washings, chiefly, and which if discharged into the harbor would by its deposit naturally tend to fill the channels. It seemed to me that more than that should be done. Another point of view, at that time very common in our country, was a purification by what was then known as the septic tank treatment. This treatment required a detention of at least 8 hours. This detention was for the avowed purpose of causing putrefaction, and by this putrefying of the sewage to remove a large amount of offensive organic matter chiefly the animal matter and to change it into liquids and thus reduce the quantity of settling suspended solid matter. I felt opposed to this treatment, although most engineers were advocating it. I could not recommend such a long detention on the Newark Meadows believing that that territory will some day become valuable, be built up, and that any septic treatment of sewage would certainly be abandoned in such localities. On the other hand, I felt that a mere retention of the grit was not enough. At that time, as I already stated, progress was being made in Europe in treating such questions. I was not yet convinced
4205 that they would be satisfactory, but to allow us to be in the right direction, I suggested at least these dimensions which have been embodied in the agreement and which were neither one nor the other of the older treatments, anticipating what has now become well established, a treatment of inoffensive sludge disposal, by what is known as the Imhoff Tank. These dimensions were embodied in that stipulation, although I could not give any more reasons for them than those I have now given.

Mr. Riker: Will you please put on the record a motion to strike out the dissertation of this witness as not responsive, not in rebuttal of any testimony of the defence, and entirely irrelevant and immaterial to the issue.

The Commissioner: Note the objection of counsel for the defendants, as to the answer of the witness.

Q. Mr. Herring, in your opinion is the detention period set forth in Complainants' exhibit No. 135 a sufficient period of time for the detention to affect the purposes aimed at?

Mr. Riker: The request is objected to on the ground that this witness is already on record in regard to the matter of writing as appears in exhibit for the defence No. 5, and is asked to contradict himself.

The Commissioner: Note the objection of counsel for the defendants.

A. Since the time this document was prepared, a large amount of evidence has been collected so that today I should somewhat increase these detention times or periods embodied in the stipulation.

Q. Mr. Hering, will the contemplated or prescribed treatment set forth in Complainants' exhibit No. 135 render the effluent to be discharged odorless, colorless, and free from visible particles of suspended matter?

Mr. Riker: The question is objected to on the ground that it is not rebuttal of any evidence in the case on the part of the defence, the evidence of the defence being contained in Complainants'
4206 exhibit No. 135; that when the effluent is discharged into the waters of New York Bay at Robbins Reef, it will not produce the conditions named in the stipulation, and that there is no evidence that the effluent itself will be of the character involved in this question.

The Commissioner: Note the objection of Counsel for the Defendants.

A. The effluent at the works will not be odorless and will not be free from suspended matter.

Q. And how as to color?

A. It will not be free from color. I mean that the settling tanks at the works on the Newark Meadows, will not remove all the suspended matter.

Q. Mr. Hering, has salty or brackish water a lower or a higher capacity to absorb offensive sewage odors and gases than fresh water has?

A. It has not.

Mr. Riker: Same objection.

The Commissioner: Note the objection.

Q. Which has it, a lower or a higher capacity?

A. The salt water has a lower capacity, less capacity.

Q. Mr. Hering when sewage is mixed with salty or brackish water, is not the odor at or near the point of discharge stronger or more offensive than if the sewage were mixed with fresh water?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It generally is.

Q. What proportion of the organic matter in sewage is partially dissolved, and what portion partially in colloidal condition, approximately?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. At first, at the point of origin there is very little organic matter dissolved, there is very little outside of the urine that
4207 enters the sewer where the organic matter is dissolved, but very soon, as the suspended solid matter is carried along, organic liquids are drawn out, matter is dissolved, and the amount of organic matter in solution increases gradually towards the outfall.

Q. Is it an advantage to treat sewage near its source of origin or some distance from its source of origin?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. That depends. It is generally found most efficacious, most economical to separate the liquids from the solids before adding any further treatment. Liquids and solids can be separated more thor-

oughly the nearer the sewage is to the point of origin. Therefore, if that separation is a desirable part of the process, it is very clear that the nearer you go to the origin, the better you can separate solids from liquids.

Q. Mr. Hering, does the effluent from settling tanks usually contain more dissolved and colloidal organic matter than the sewage before entering the tanks especially if that sewage is septic?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It does contain more solids in solution, depending upon the time that it has taken to pass through the tank.

Q. Mr. Hering, in view of the characteristics of the sewage and of the waters of Upper New York Bay, and of your recent studies of the action of sewage and sewage effluents as contemplated in exhibit No. 135, would you now modify the recommendations you made to the Passaic Valley Sewerage Commission on December 31, 1907?

Mr. Riker: Same objection.

The Commissioner: Note the objection.

Q. When I had reason to believe that modifications might be made, I communicated this fact to the Commissioners, but they
4208 took no action. I also communicated the fact to the Public Press, clearly stating that in my belief from the discoveries that had been made, it would be well to have a revision of the studies, because then the results would be better and the expenses might be less. I have the same opinion to-day.

Q. What modifications are embodied in your opinion as you now hold it?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I believe, although the study has not been made, and conclusions cannot be reached without the expenditure of a good deal of effort, analyses, studies and so on, that economy would result from a quicker interception of the suspended matters, and thereby getting a much better sewage to be discharged into the water courses. The question, the answer to which I do not know is how far the separation can be carried economically, nor at what points or for what cities or towns it would be best undertaken. Furthermore, I am not clear, and I do not see how much clearness could be had without the necessary studies, analyses and experiments, as to whether for some time or not it might be sufficient to discharge the effluent thus freed from solid matter, nearer by, and thus save immediate expense of a large tunnel into New York Bay.

Q. Well, what expression, "the discharge nearer by," what do you really mean by that, Mr. Hering?

A. By that I have in mind the lower part of Newark Bay, near the Kill van Kull, utilizing for dilution chiefly the waters of the Kill van Kull and the waters of Newark Bay, but regarding this as I stated, I have no positive information; I don't know whether it

would be economical, and therefore, I think those studies were entirely reasonable. I think they should have been made.

Q. Mr. Hering, have you examined any of the sewage disposal systems of Europe?

Mr. Riker: The same objection.

4209 The Commissioner: Note the objection.

A. Yes sir; almost all of the sewage disposal systems of western Europe that are of interest and value.

Q. Do you know of any sewage disposal system anywhere in the world where septic sewage has been successfully treated so as to render an effluent odorless and unobjectionable?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes sir, there are in England a number of plants where the sewage is septic and where it is then oxidized in sprinkling filters and is turned out satisfactory to the Government, and in our country here the most prominent case that I am thinking of is Saratoga Springs, where the sewage is made very septic, and where it is afterwards treated on intermittent sand filters, and where it is turned out quite satisfactorily.

Q. Is that the best mode of oxidizing sewage, the sand filtration?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. In my opinion intermittent sand filtration is the most perfect and the best way in which sewage can be oxidized. The oxidation is carried to the highest degree. The results are therefore, better than, for instance, in sprinkling filters, which is generally the most economical plant for oxidizing sewage, but it is not as efficient.

Q. Is intermittent sand filtration or sprinkling filters any portion of the contemplated sewage disposal system of the Passaic Valley Sewerage Commissioners?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I think not, although I am not informed as to what it is proposed to do now.

Q. In speaking of the interception of the sewage of the Passaic Valley District, how near to the source of origin of the sewage

4210 would you think that most desirable?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The separation of the suspended matter from the sewage should be undertaken, as I have stated, as near the origin as possible or practicable, and that will depend upon the particular location of the sewer, and the availability of ground and a number of other things that would have to be examined; but I see no reason why there would have been a great difficulty in selecting such places.

Q. Relative to the communities contributing the sewage would it be more desirable to treat the sewage adjacent to the community that contributed it or at some distance from that community?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. The word "desirable" would depend upon two things, the cost and the possibility of nuisance. Now, if it is much cheaper to treat the sewage nearby and more expensive to take it away, it would of course, in that way be more desirable to treat it nearby. So far as the nuisance is concerned, it is my personal belief that we have reached a state of development when it is practicable to collect and convey, discharge and dispose of sewage without an odor.

Q. By what method?

A. In the first place by the proper construction of the collecting sewers, notably by giving them a very smooth interior, which is usually accomplished by vitrified pipes; secondly, the keeping of these sewers clean by suitable flushing and other means of cleansing as we find in a large number of cities, so that from the house to the sewer outfall, there should be no odor from the sewers, and there is none in a great many cities. It is perfectly practicable to enter the sewers in Europe—ladies have entered them; I have taken my boys into the sewers, and found no offense. There are some sewers
4211 in this country of which you might say almost the same, although we do not give the same care to keeping sewers clean here that they do in Europe. Therefore, the sewage can and should be delivered at the outfall of a city without an odor. Now, then, the question is of further treating it. It has already absorbed oxygen and there is less oxygen in solution. The danger point of our putrefaction is approaching. Therefore, the next point is to get at the matter which causes the putrefaction, and that is primarily the suspended matter before it is dissolved. If you can settle it out inoffensively by the modern treatment, and allow it to change itself inoffensively into a material which remains inoffensive, then you have permanently removed from the whole sewerage system the greatest and chief cause of foul odors. It is an imitation of nature's process, to illustrate it, of rotting leaves in the forest, a gradual transformation of the leaves into humus, into black garden soil; and that is precisely what the sludge is that results from the Imhoff Tanks; it resembles in color and appearance the garden soil; it resembles also in odor. Of course, you will see in it a large number of particles which are different; for instance, hair, which you do not see in the humus. You also see little particles of bone and such matter.

Q. Mr. Hering, can sewage when treated by screening with 4/10 inch mash screens and by sedimentation be more efficiently treated by the separate communities that contribute the sewage, or can it be more efficiently treated by collecting it from the communities and treating it at a considerable distance from its source of origin.

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. It can be more efficiently treated by the separate communities because the suspended matter is not broken up so finely, and much of it can be retained even by screens, whereas if it has been conveyed a long distance and churned and comminuted or broken into small particles, screens will do very little good in keeping
4212 out suspended matter. For that purpose they are using screens now in Europe of but one millimeter mesh, because it is found that unless you set such fine screens the amount of solid matter that you keep out is too little to make screening worth while. With the Imhoff Tank screening it is not necessary at all except to keep out very bulky matter. Screens 3 inches in mesh are considered sufficient, because the suspended matter retained in the tanks either floats to the surface as grease or it settles to the bottom, and is there gradually converted into inoffensive material.

Q. If the sewer of the Passaic Valley contributing communities was treated at each community with the fine screens and sedimentation that you have described, could the effluent then safely be discharged into the Passaic River?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. I don't think that the effluent could be discharged into the Passaic River.

Q. Without further treatment?

A. Without further treatment.

Q. What further treatment would you suggest?

Mr. Riker: The same objection.
The Commissioner: Note the objection.

A. A further treatment would be possible by three methods, one of which is not practicable, and that unfortunately is the best one, the intermittent sand filtration. The second would be by sprinkling filters. In that way you could oxidize the sewage to an extent that would enable a discharge to be allowed in Newark Bay. The third method, I believe would be the one to be advised, namely a dilution with the waters that are available for such purpose, and to an extent which they will permit. Beyond that extent it would be necessary to adopt some other method of oxidation, and then some oxidizing works, would in the future have to be installed.

Mr. O'Sullivan: He is your witness, Mr. Riker.

4213 Cross-examination by Mr. Riker:

Q. Mr. Hering, you think the effluent as it will be produced from the works that are described in the plans which you prepared could safely be discharged so far as a nuisance is concerned into the Kill van Kull?

A. If the solid material is excluded by sedimentation, if the trade wastes are kept out, as I believe the law provides for, I am satisfied that for some time the effluent could be discharged into Kill van

Kull without creating a nuisance. How long that will continue, I am not prepared to say with any information that I have.

Q. Well, the modifications that you suggested had to do with the point of discharge, had they not; you thought there should be a new study as to the point of discharge?

A. No sir; not with reference to the point of discharge, but to the way of treating the entire question, as to whether the sewage should be collected, conveyed and discharged just as it was proposed in this stipulation or whether there might be some changes.

Q. As to the point of discharge?

A. No, as to the treatment. The sludge removal is, in my mind, more than anything else.

Q. Why have you testified in your direct evidence there as to a proposed discharge in the Kill van Kull as being one of the subjects which you thought should be studied?

A. I should certainly, with the additional treatment of an early sludge removal, say that whole queston should be studied again.

Q. And with the belief that the effluent could be discharged without producing a nuisance in the Kill van Kull?

A. No, I don't say that positively; I say it is a matter that should be studied.

Q. Do you know whether or not it has been studied, as a matter of fact?

A. I do not.

Q. Do you know the relative length of line required to discharge into the Kill van Kull as compared with that discharged at Robbins Reef?

4214 A. It would be less expensive.

Q. I did not ask you that; I wish you would answer the question?

A. Length of pipe?

Q. Yes, length of pipe, do you know?

A. I don't know; I don't think there is a very great difference, but it certainly would cost less, and that is the main thing with an engineer.

Q. Have you made a study to find out whether it cost less?

A. No.

Q. Do you know whether or not the Passaic Valley Sewerage Commissioners have made a study to find out whether it would or not?

A. No sir.

Q. Well, didn't you say that your suggestion had not been observed in regard to restudies and further studies?

A. They had not been observed at the time, or shortly after the time when I made the suggestions.

Q. How long ago did you make the suggestions?

A. I guess that must have been 4 years ago, something like that.

Q. Now, Mr. Hering, I show you Defendants' exhibit No. 5, being a communication addressed to the Passaic Valley Sewerage Commissioners, under date of March 25th, 1909, and purporting to be signed by you, among others; do you recognize the signature? (Counsel hands witness paper)?

A. I recognize the signature. (Witness examines paper).
Q. Do you recognize it?
A. Yes sir; if you will allow me, I would like to read it through.
Q. Certainly. (Witness reads paper).
A. That is all right, sir.
Q. Who was Edlow W. Harrison?
A. He was the Chief Engineer, I believe, of the Passaic Valley Sewerage Commission.
Q. And who was George W. Fuller?
A. My partner.
Q. This report represents your opinion at that time?
A. Yes sir.
Q. Represents your opinion now?
A. Substantially so, yes sir. There are some details here which might be modified in view of more information, but substantially it does.
4215 Q. How long were you associated with the Passaic Valley Sewerage Commissioners?
A. I don't know when the point of termination occurred, but from the time when they were organized.
Q. As early as December 13th, 1902?
A. Is that when they were organized?
Q. No, I think they were organized a little later than that, perhaps?
A. Well, I was connected with this project from its inception, but it was not the Passaic Valley Sewerage Commissioners; it was the State Sewerage Commission I think, first, that had charge of this matter.
Q. Well, do you remember in connection with a body known as the Passaic Valley Sewerage and Drainage District of Newark?
A. I don't remember that particular name, sir.
Q. Do you think your connection with this project, then, began as early as December, 1902?
A. I think so.
Q. It continued how long?
A. I think until perhaps two years ago, I think, or two or three years ago—three years ago, I guess.
Q. It was more than that, wasn't it?
A. Further back?
Q. Three years ago?
A. Maybe three years ago, I think this document that you just gave me to read was the last communication that was ever sent to them by me.
Q. March 23rd, 1909?
A. That is the last communication I ever sent.
Q. Mr. Hering were you in the employ of the Commission?
A. Yes sir, part of the time.
Q. And you were engaged in the formation of the plans for the purification of the Passaic River?
A. The early plans: just in a general way, because they did not have the funds to make very exhaustive studies, and we used our

judgment as much as possible, based on our experience, instead of verifying all the details by surveys and investigations. However, we did make enough investigation with the means at hand to satisfy us with reference to the conclusion.

Q. And did you approve of the plans that were adopted, so far as you know, by the Commissioners?

A. Some three or four years ago, yes sir.

4216 Q. And did you take into consideration the proposal to establish separate separation works for the separate municipalities?

A. No sir.

Q. Why not?

A. Because it was not at that time known that such a proposition was practicable, for this reason: My first engagement on this work, I think was by the State Sewerage Commission, was brought about in this way—all the communities had prepared plans for purifying the sewage on their own territory from Paterson to Newark, inclusive. These propositions were all considered by the State Sewerage Commission. They were at a loss to know what to do, and they appointed a commission consisting of three engineers to give an opinion. We found after a very exhaustive inquiry that none of the projects that had been proposed for treating the sewage of Paterson and Passaic and of the other cities including Newark, could be recommended; and we were ready to turn down the entire lot and say that we could not approve of any. Then it occurred to us that it might be possible to unite all of the towns with a trunk sewer, as has been proposed before that by an engineer, and we looked into this proposition, although without instructions. This was a proposition to discharge the sewage at the lower end of Newark Bay. We came to the conclusion, however, that this solution would not last very long. I believe the figure was made—but that was merely an estimate—it might last ten or fifteen years and then it might become objectionable. We then turned to New York Bay, and that was the origin of the proposition to discharge the sewage into a much larger body of water with the expectation that the time when this would no longer be possible or practicable was so remote that it did not have weight at the time when making the recommendations.

Q. That discharge was untreated sewage, wasn't it, that was proposed at that time?

A. Yes sir, that was all untreated sewage.

Q. Now, what I want to know is why in your complete connection with the proposal down to 1909 or 1910, you did not suggest the separate cleaning and the sedimentation of the separate municipalities as you now say is desirable from some point of view?

A. As long as I was engaged, I had no other information 4217 except that which was before us, and under those circumstances, it was utterly impossible or impracticable I will say, to have every community treat its own sewage.

Q. Was it impracticable to have them screen and sediment it?

A. Well, that was not an entire treatment of sewage.

Q. That was the question that was asked you on the direct examination, Mr. Herring, whether that was desirable?

A. That is, of course, desirable; but it is not a complete treatment of the sewage?

Q. Is there anything new about screening and sedimentation as compared with your work with the Passaic Valley Sewerage Commission?

A. There is something new regarding sedimentation which is so materially and substantially new that it practically revolutionizes all sewage treatment.

Q. What is that?

A. That is the inoffensive sludge decomposition.

Q. By the Imhoff Tank?

A. Yes sir.

Q. So that, that is what you were testifying to in answer to the direct question as to sedimentation and screens, as applied near by by the separate municipalities?

A. Yes sir, if it is done today; the sedimentation today by means of the Imhoff method is wholly different matter from what it was five or six years back, when we were not yet familiar with it.

Q. Well, what additional treatment would be necessary for the effluent after it has passed through the Imhoff Tanks, then?

A. The additional treatment of the effluent when it is fresh, and that is the other question that is of great importance, is either an oxidation by water or an oxidation on land by what we call filtration, although the sprinkling filter is not a true filter, but it is so called.

Q. And you think it would be an economical thing for those separate municipalities to install the Imhoff Tanks and the Sprinkling filters or other oxidizing devices for the effluent as compared with the Passaic Valley Sewerage scheme?

4218 A. It is very economical for some, those which I have investigated.

Q. And you think it would be as economical to treat the municipalities separately, do you?

A. I have only investigated the question so far as a few towns are concerned; I am not prepared to say whether it would be applicable to any of the other towns, because I have not investigated it. But I did urge in public print some years ago that such investigations be made. I do not know whether they have been made or not. I merely believed at that time that they had not been made, because—or some little time afterwards—because of some remarks which I saw in print emanating from some employees of the Commission.

Q. And since you severed your connection with the Commission, you have been retained by Montclair, haven't you?

A. Yes sir, I have been retained by Montclair, Orange and East Orange.

Q. Municipalities which have refused to come into the joint sewer project?

A. I believe they have so far refused to go in.

Q. And you have there recommended the Imhoff System, I think, have you not?

A. Yes sir.

Q. What interest have you in the Imhoff system?

A. If you mean financial interest, not one cent; never had, have not, and never will have.

Q. If the municipalities in question do not adopt the Imhoff system, is there any way that you know of in which they can dispose of their sewage independently of the Passaic Valley Sewerage project?

A. I do not.

Q. When you made the report which is Defendants' exhibit No. 5, dated March 25th, 1909, had you made an estimate of what the Passaic Valley sewer would cost?

A. Yes, sir.

Q. How much did you estimate?

A. The estimate which we made at that time, I think, was about $13,000,000.00.

Q. And you know that the Commissioners were considering the adoption of your plans and the discharge of the sewage upon that plan into New York Bay, did you not?

A. Yes sir.

4219 Q. And contemplated the expenditure of $13,000,000.00. upon it, did you?

A. Yes sir.

Q. Are you under subpœna here today?

A. I have been requested to be here.

Q. I am asking you whether you are under subpœna, under process of the Court?

A. You mean whether I have a—whether I saw a piece of paper on which I——

Q. Do you know what process of the court is?

A. Well, a subpœna, I remember, because I have sometimes been shown a subpœna.

Q. Are you here under subpœna?

A. I do not think I have seen a piece of paper which you call a subpœna.

Q. Don't you know whether you are here under subpœna or not?

A. I don't know, no sir.

Q. You don't know whether you have received a subpœna?

A. I have been requested by Dr. O'Sullivan to be here.

Q. Are you here under retainer?

A. No sir.

Q. You are not to be paid for your testimony?

A. Yes sir.

Q. You are to be paid?

A. Yes.

Q. How much are you to be paid for being here?

Mr. O'Sullivan: I object to that and instruct the witness he need not answer.

The Commissioner: Note the objection of counsel for the Complainants.

A. I am here expecting to be paid what I am paid from almost all other clients, and what is the regulation charge under the code of the American Institute of Consulting Engineers, which is a minimum fee of $100.00 a day.

Q. Do you understand the purpose of this suit?

Mr. O'Sullivan: I object to that.

The Commissioner: Note the objection of Counsel for the Complainants.

4220 A. I presume the purpose of this suit is to prevent the State of New Jersey from fouling New York Bay.

Q. Don't you understand the purpose of the suit is to prevent the State of New Jersey and the Passaic Valley Sewerage Commissioners from putting into actual operation the plan which you approved and submitted to them?

A. I don't know how far the details go.

Q. You know that you are here at the request of the Complainants, don't you?

A. Yes sir.

Q. And you know that the purpose is to prevent the carrying into actual effect of plans which you have submitted and which you have approved in Defendants' exhibit No. 5, don't you?

Mr. O'Sullivan: I object to the question; it relates to nothing that has been brought out on the direct by this witness.

Mr. Riker: It relates to the competency and qualifications of this witness.

The Commissioner: Note the objection of Counsel for the Complainants.

A. I know that, sir, and I have already testified that if I were to advise on this Passaic Valley Sewerage treatment, I should certainly advise differently owing to the very radical changes that have occurred since that time; and in view of the present economical possibilities of treating sewage in a better way, all of which would cause me, as a consulting engineer, to advise something better than I did a few years ago, when nobody on this earth knew about the possibilities of which we know today, and of which we have absolute proof.

Q. Do you mean to say by that that you are now of the opinion that the discharge of the effluent as proposed will not produce the results that are guaranteed in Complainants' exhibit No. 135 which is before you?

4221 A. I am of the opinion that for a while and for a time—how long I do not know—this discharge as specified here with only slight exceptions that would no doubt be made in the course of developments, will not cause a nuisance, that is, for a certain time, the length of which I do not know. I know today that another way is possible, and a better solution is possible by utilizing discoveries

and practice- that have been made since that time, and I always recommend that which is best known at the time of the recommendation.

Q. I ask you again whether you have changed your opinion as to the effect of the effluent which will be produced at the proposed pumping station on the Newark Meadows when discharged into New York Bay, as to whether it will or will not for the maximum sewage intended to be conveyed by this sewer, will result as specified in the stipulation which is Complainants' exhibit No. 135?

A. I don't think that it would cause a nuisance today, just as I have stated before.

Q. That maximum discharge of 360,000,000 of gallons today?

A. That I am prepared to say today.

Q. What has changed your mind in regard to the nuisance, if it is that, since you made your report and recommendations to the Passaic Valley Sewerage Commissioners, embodied in Defendants' exhibit No. 5?

A. The discovery of the inoffensive sludge treatment of sewage.

Q. How does that affect the results which will be obtained from the proposed treatment that is embodied in Complainants' exhibit No. 135 and its effect in New York Harbor?

A. It has a very great effect, because if you keep the sludge out and convert it inoffensively into material that is not objectionable, you can utilize this means of sewage disposal, for a very very much longer time, how long I cannot say. Therefore, it is decidedly more economical and to be advised.

Q. Well, what I want you to answer, Mr. Hering, if you will, is whether or not you have changed your mind as to the result
4222 in New York Harbor of an effluent produced as proposed and described in Complainants' exhibit No. 135, whether it will cause a nuisance in New York Harbor?

A. Not today, as I have stated already.

Q. Well, when will it?

A. That I have stated nobody can tell. It is a question of time how long this will last, and that is precisely the question which an engineer meets with every one of his works, they are built up to a certain time. Now, if he can effect some modification, some improvements, it will last a longer time.

Q. That does not mean anything more, does it, Mr. Hering, than that the more you purify the effluent the longer you can discharge it; does it mean anything else?

A. That is what it means.

Q. It does not require an expert to know that, does it?

A. Sometimes it does.

Q. How long did you calculate that the Passaic Valley sewage would require additional purification so far as the length of time of its discharge was concerned; in other words, how long did you calculate the life of this sewer to be?

A. I did not calculate it; there is no way of calculating it.

Q. You did not calculate it?

A. No sir.

Q. You did not design it for any specific length of time?

A. The sewers were designed for a certain population and a certain amount of sewage, but just what the effect would be of the discharge, it was utterly, impossible for anybody to calculate with the knowledge then available.

Q. Now, Mr. Hering, the sewers are proposed for a definite carrying capacity, are they not?

A. Yes sir.

Q. And taking the maximum capacity, carrying capacity, of the sewers, do you think there is any question that an effluent of sewage that is represented by the total carrying capacity of the sewers, treated as specifically described in Complainants' exhibit No. 137, will not result in a nuisance in New York Bay?

A. I cannot tell.

4223 Q. Why didn't you advise the Commissioners to that effect when you *are* called upon to advise them, if you could not tell?

A. Because there was not a man living who could tell.

Q. Didn't you recommend they should go into this project?

A. Yes, sir.

Q. With a sewer that was designed to have a specific carrying capacity?

A. Yes sir.

Q. And didn't you advise them that in your opinion there would be no nuisance produced in New York Bay from that sewer?

A. Yes sir, that there would not be at first.

Q. Have you changed your mind?

A. I have already stated that I have changed my mind in the prio*f* method of treating the sewage. It is today possible to lengthen the life of the works and of the discharge ver- materially by a better treatment of sewage which has been discovered since that time.

Q. Is that better treatment impossible of application to the sewage at the proposed disposal plant?

A. Yes sir.

Q. Why?

A. Because the sewage when it reaches the disposal plant—I don't know what you call the disposal plant, the outfall or the pumping station—well, at either place, I will say the character of the sewage is such that it would be very difficult and expensive to treat it in the Imhoff way, because of the fact that the sewage has been communuted, that the settling will be very slow, that the sewage would become septic or likely to become septic, and that the settling time would have to be so long that altogether there would be the creation of a nuisance, and that is not what I should recommend.

Q. And since you have ceased your connection with the Passaic Valley Sewerage Commissioners, and ceased to be under their pay, you have come to the conclusion that the plans which you have recommended should be displaced by some others, is that it?

A. Partly so, but if I may substitute, I informed the members

of the Commission and the President of the Commission of all these facts by personal visits, and by a personal report that
4224 a re-investigation of this question should be made.

Q. That is since you ceased to be connected with them, is it not?

A. Yes sir.

Mr. Riker: That is all.

The Witness: I don't know whether that is literally true or not, but during the latter part of the engagement or afterwards. I do not know exactly when the engagement terminated, there was no definite time.

Mr. Riker: That is all.

Redirect examination by Mr. O'Sullivan:

Q. Mr. Herring, directing your attention to Defendants' exhibit No. 5, at page 3, I ask you if you recall reporting that the very finely divided suspended organic particles and the dissolved organic matters of the sewage will, under the proposed conditions of dispersion be carried into the water into which they will be discharged?

A. Yes sir.

Q. Mr. Hering, directing your attention to page 1 of Defendants' exhibit No. 5, I ask if you recall—taking the second paragraph of that report,—this fact: That: "This statement is prepared for the purpose of securing cooperative action to decide the details of this method in a manner satisfactory to the parties in the pending suit between the States of New Jersey and New York and the United States in accordance with the understanding arrived at during the conference held in the office of Attorney General O'Malley, in New York City, on March 11th, 1909." I ask you if you recall that that statement was prepared with that object in view?

A. I do.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. And the object was to be carried out and into effect by the construction of the sewer was it not?

A. I presume so; the construction of some sewer, and the construction of some works.

Q. And the plans that were recommended by you to the Commissioners were intended to carry this into effect, were they not?

—. ——.

4225 Q. And they are embodied in Complainants' exhibit No. 135?

A. Yes sir.

Q. You understood at the time that they were satisfactory to the City of New York, did you not?

A. I did not have any knowledge of that at all.

Mr Riker: That is all.
Mr. O'Sullivan: That is all.

Adjourned to June 27th, 1913 at 10.30 A. M.

Supreme Court of the United States, October Term, 1912.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
against
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

NEW YORK CITY, June 27th, 1913—10:30 a. m.

Before James D. Maher, Commissioner.

Appearances: William J. O'Sullivan, Esq., Special Counsel for the People of the State of New York, Complainants;
Adrian S. Riker, Esq., of Counsel for the Passaic Valley Sewerage Commissioners, Defendants.

4226 Met pursuant to adjournment.

J. WILLIAM GRIFFIN, a witness called in behalf of the complainants, in rebuttal, being first duly sworn by the Commissioner, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name?
A. J. William Griffin.
Q. Where do you reside?
A. In Jersey City.
Q. Professionally, what is your occupation?
A. I have been Superintendent of the Water Works of the Water Department of Jersey City since the year 1906. Previous to that I was Superintendent of the New York and New Jersey Water Company for a period of ten years and have had extensive experience in public works construction and operation.
Q. Were you in charge of the litigation conducted by Jersey City against the Jersey City Water Supply Company?
A. I was in complete charge of that litigation and conducted the case which extended through a period of four years.
Q. Did you ever reside in Arlington, New Jersey, and if so, when?
A. I resided in Arlington, New Jersey from October 1898 to 1909.
Q. Are you familiar with the pollution of the Passaic River by the sewage of the cities in the Passaic Valley?
A. I am.
Q. Have you knowledge of the plans of the Passaic Valley Sew-

erage Commission relative to the disposal of the sewage of the Passaic Valley district?

A. I have.

Q. In your opinion will the discharge of this sewage as proposed at Robbins Reef Light in accordance with these plans affect the health and property of the citizens of Jersey City?

Mr. Riker: One moment. I object on the ground that it is immaterial and irrelevant and not in issue in this case.

The Commissioner: Note the objection of counsel for the defendants.

A. It will. I appear voluntarily in this case to protest
4227 against the discharge of this sewage into New York Bay on the ground that it will create a nuisance in the waters of the Bay which will seriously affect the business interests the property interests and health of Jersey City.

Q. On what do you base your opinion that the discharge of this sewage will be a damage to Jersey City property and to the health of Jersey City's citizens?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I know now that the sewage from these towns creates a nuisance in the Passaic Valley, affecting the health and property of the citizens therein and that this nuisance is the chief reason why the cities in the Passaic Valley have joined in a plan to carry the same out of the valley through the trunk line sewer proposed by the Passaic Valley Sewerage Commission. I believe that this pipe line will simply transfer the nuisance which exists in the Passaic Valley to the water front of Jersey City, and the other municipalities on New York's upper Bay. This is apparent on inspection of a panoramic map which I herewith produce. It shows the relation of Jersey City to the site of the area of discharge. (Witness produces map.) This map has got several proposed improvements on it that do not exist at the present time, such as the Ship Canal of Newark and the Hudson River Bridges.

Q. Does that panoramic map show the relation of Jersey City to the proposed sewer outfall and to the location approximately of the sewage disposal works on the Newark Meadows?

A. It does.

Mr. O'Sullivan: I offer that map in evidence for the purpose of showing the relative location of Jersey City to these two points, and ask that it be marked in evidence as Complainants' Exhibit No. 217.

Mr. Riker: I want to ask a few questions about this.

Cross-examination by Mr. Riker:

Q. Did you make this map?

A. No, sir, I did not.

Q. Did you ever observe this locality from a point corresponding?

A. Well, only my general knowledge of the situation.

4228 Q. Your general knoweldge of the situation corresponds with that?

A. Yes, sir.

Mr. Riker: The offer is objected to on the ground that it is not properly proved, is irrelevant, immaterial and not rebuttal of any evidence offered by the defense.

The Commissioner: Note the objection of counsel for the defendants.

Said map was received in evidence and marked Complainants' Exhibit 217.

Mr. O'Sullivan: The is your witness, Mr. Riker.

Q. I show you Complainants' Exhibit No. 135, and ask you whether you have ever seen this exhibit, or a copy of it? Examine it, please?

A. I have seen a copy of it, yes, sir.

Q. Is the discharge which you say you think will prove to be injurious to Jersey City, the discharge which is described as to its results in the second stipulation in that instrument? (Counsel hands witness exhibit No. 135.) Examine and read it?

A. (Examining exhibit.) It is.

Q. You think that an effluent which when discharged into the waters of the New York Bay would produce no visible suspended particles coming from the Passaic Valley Sewerage and from which there will be an absence of deposits objectionable to the Secretary of War of the United States, and in which there will be an absence in New York Bay and its vicinity of odors due to putrefaction of organic matters, contained in the sewage of the Passaic Valley, as thus described, and from which there will be a practical absence on the surface of New York Bay of any grease or color due to the sewage of the Passaic Valley and from which there will be no injury to the public health which will be occasioned by the said sewage in the Bay of New York in the manner proposed, and no public or private nuisance created thereby—will be a nuisance to the City of Jersey City?

A. I do.

Mr. Riker: That is all.

4229 Redirect examination by Mr. O'Sullivan:

Q. Mr. Griffin, have you also had your attention directed to the screening and the sedimentation to be employed in the production of that effluent?

A. I have.

Q. Will the means and the plant inscribed in Complainants' Exhibit No. 135 produce the effluent, the results of which are guaranteed in that stipulation?

A. It will not.

Mr. O'Sullivan: That is all.

Recross-examination by Mr. Riker:

Q. If they do produce the effluent which is guaranteed in that instrument, in your opinion, there will be a nuisance created?

A. It is impossible for them to produce such an effluent.

Q. That is your opinion?

A. It is, yes, sir.

Q. If they do, however, contrary to your opinion, produce such an effluent, is it your opinion that it will create a nuisance?

A. According to the plans that I have seen, it is impossible to produce it.

Q. I do not ask you that; I ask you to answer my questions, that if the effluent does result as guaranteed, do you think there will be a nuisance created thereby in New York Bay?

A. I will have to answer that as I answered it before, that you cannot produce an effluent of that kind according to your plans. If the effluent that they propose, according to the specifications of the United States Government were procured, there would be no need of carrying it into New York Bay, they would be as all up-to-date disposal works, and that is to discharge it into the nearest water way.

Q. You don't mean to be understood, do you, that such an effluent cannot be produced?

A. I do not, because it can be; but not according to the plans that have been shown me.

Q. Now, if such an effluent is produced, which you say is possible, you think it nevertheless will be a nuisance if discharged into New York Bay?

4230 A. I do not, but the only thing I say about that is that you would not carry it into New York Bay if you proposed to discharge an effluent of that character.

Mr. Riker: That is all, Mr. Griffin.

Mr. O'Sullivan: That is all.

OLIN HENRY LANDRETH, a witness in behalf of the Complainants, recalled, in rebuttal, testified as follows:

Direct examination by Mr. O'Sullivan:

Q. What is your full name, Professor?

A. Olin Henry Landreth.

Q. Have you testified previously in this suit?

A. Yes, sir.

Q. Has your attention been directed to testimony given by Mr. George A. Johnson, an expert witness called on behalf of the defendants in this suit?

A. It has.

Q. Have you taken up any matters testified to by Mr. Johnson, and if so, state what?

A. I have. I have taken up the testimony given by Mr. Johnson concerning his tests with colored liquids for the purpose of conclud-

ing as to the diffusion of sewage when discharged into the Upper Bay at Robbins Reef.

Q. Have you conducted any experiments yourself along the lines testified to by Mr. Johnson?

A. I have. I have made a series of experiments to determine the influence of the velocity with which the sewage is discharged on its appearance on the surface. Mr. Johnson's testimony went to the question as to the probable appearance of sewage on the surface of the harbor, as judged by his examination of the appearances or non-appearances of a colored dye on the surface of the harbor waters, and he endeavored to show that his experiments with the colored dye would lead to corresponding results with sewage. I desire to show that granting his experiments of the colored dye, they are sufficiently dissimilar to what will take place with the sewage
4231 to render a conclusion as to the identity of results of little value. The experiments made by Mr. Johnson with the colored dye differed from the conditions which will prevail in the discharge of sewage in two essential particulars. In the first place, the experiments with the dye by Mr. Johnson were made at a high velocity of discharge, the actual discharge of sewage from the future sewers according to the specifications and general description of that system will be at a low velocity. The experiments made by Mr. Johnson were conducted by discharging the colored dye in a vertical downward direction; the discharge of sewage from the sewer outlets will be either a vertical direction, or, at best, in a horizontal direction, and my experiments go to show that there is a very striking contrast in the appearance of a dye on the surface of water when discharged in a downward direction as compared with either a vertical, upward or even a horizontal direction. I also made comparative results to observe the effect of the difference in salinity of the water into which the dye was discharged as between pure, fresh, soft water on the one hand and sea water of the average salinity of the harbor water on the other. I also conducted some experiments for the purpose of showing the influence on diffusion of the quietness of the water into which the discharge was made. That, however, was not in rebuttal of anything which Mr. Johnson said, but was to throw additional light on the question and that series is not yet complete.

Q. Does motion and quiescence influence diffusion?

Mr. Riker: The question is objected to because it is not rebuttal of anything in defendants' evidence.

The Commissioner: Note the objection of Counsel for the defendants.

A. It does.

Q. Will you describe in detail the experiments which you conducted, describing first the apparatus and the agents em-
4232 ployed and the observations made as the result of your experiments?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes, sir. The apparatus employed comprised a large reinforced concrete tank, sunk in the ground 20 feet in length and 10 feet in width and 5 feet in depth. The surface of this tank was colored white, so as to render it possible to detect faint differences of color in the water. The coloring agent employed was a dye of the same color and strength of color as that employed by Mr. Johnson. The discharge was made through a system of piping extending from the upper portion of the building down to the tank with a portable pipe having an orifice, with arrangements to regulate the velocity and arrangements also to alter the direction of the jet. The jet could be turned vertically downward or vertically upward, or horizontal in either position, or in the four directions of the quadrant, and could be lowered to any height, and could be placed in any part of the tank. The velocity was regulated by callibrating a valve on the pipe so that by setting the valve at any given degree of opening, any velocity could be obtained from zero to 15 feet per second of discharge. We actually employed for most of the series velocities of 1½ to 2 feet per second, and velocities of 10 feet per second. In Mr. Johnson's experiments he employed a velocity of about 10 feet per second. He indicates that, not by stating the velocity, but by stating the volume of coloring matter discharged per second, and also by stating the diameter of the discharge pipe, and from that a simple computation indicates that his velocity in most of his experiments was 10 feet per second, and that in a few of them it dropped a little below 10 feet a second, but I think in no case below 9 feet a second. The rates of discharge when the sewers are discharging at their maximum into the bay will according to the plans thus far indicated produce a discharge of approximately 2 or 2½ feet per second, of liner velocity, into the bay. The observations made were
4233 first to direct the jet in a horizontal direction and to open the valve to a slow velocity, a velocity of about 2 feet per second, and to discharge a certain quantity of coloring matter, and then to move the apparatus to a portion of the tank where the water was clear and at once discharged the same quantity at 10 feet per second, and this was repeated in the reverse order, starting again with the high velocity and closing with the slower velocity; and the results were that the high velocity in every case produced a greater diffusion of the colored matter in the water than did the low velocity, thus making it more difficult to ascertain or discern the appearance of the colored dye on the surface than it would have been had the velocity been lower. The next series which were conducted for the purpose of showing the effect of direction were made by discharging the colored dye at velocity of 10 feet per second in a vertical downward direction, and at different depths of water starting with 5 feet, again with 4 feet, 3 feet, 2 feet, and 1 foot in depth. In every case the discharge of liquid descended to the bottom of the tank where it struck the floor of the tank and spread out in a thin circular sheet, diffuse and so thin that even in the case of the salt water it failed to rise and did not rise, of course, in the fresh water, but remained on the bottom. Then the next step in that series was to change the direction to vertically upward, and in that case the colored jet appeared at once

on the surface, whatever the depth of discharge. It was only a little later when the maximum depth was used than when the first depth was used. But in each case the colored dye came to the surface in a compact form or cylinder, and as soon as it struck the surface, spread out in a circular disc in all directions just like that on the bottom. The third step in that series was to project the jet of colored dye in a horizontal direction at the velocity employed by Mr. Johnson. In the Fresh water the jet or colored portion of water which escaped moved horizontally and diffused laterally, forming substantially a horizontal cone with the vortex at the
4234 point of discharge and the base at the farther point. When I speak of that as a cone I want to qualify that by saying that the sides of the cone were not straight, but curved, so that the diameter of the base of that cone increased faster than the length increased. It was, therefore, a cone with concave sides, if we may call that a cone. In the case of salt water that same cone was formed except that it tended to rise and the base of it approached the surface and ultimately reached the surface, while nothing occurred of that nature as to rising or sinking when fresh water was employed. This series of observations on the influence of direction was repeated in different directions and at different depths. When the discharge was near the surface of the tank, the base of the cone reached the surface, naturally much sooner than it did when it was placed at a lower depth, but, apart from that, in no case did the color reach the top except by expansion of the base of the cone whereas in the case of the harbor water, with the salinity, the whole cone bent upward and reached the surface not only by expansion of the cone, but also by the buoyancy, causing the cone to rise to the surface. My experiments also included a series which has not yet been completed, showing the effect of quietness of the water into which the colored jet was discharged. Thus far the results indicate without any exception, and without any contradictory observations, that diffusion is accomplished primarily, if not solely, by the physical movements of the water into which the material is discharged, and that that state of movement or non-movement depends on the time which has elapsed since some cause of agitation has occurred. In the case of tanks recently filled with a hose, although the water seemed to be entirely quiescent, so far as indicated by any eruption or ripples on the surface is concerned, it was plainly ascertained that the water was internally moving, but that that motion, those internal eddies and movements were gradually overcome and that the water came
4235 to rest gradually with time, and that water which was allowed to stand for 24 hours in this tank without any disturbing cause, while it still had very decidedly less movement internally than when originally filled, it also had some movement and as judged by small size experiments, not on the large tank, but on the glass jars, the effect of long continued rest on producing quietness was extended still further for two or three days. That covers substantially the general results of the series and experiments with dyes.

Q. What conclusions did you draw from your experiments, and as applied to the experiments of Mr. Johnson, what criticism do they imply from your observations?

Mr. Riker: The question is objected to as not being proper rebuttal; the question should be directed as to the specific testimony of the defense.

The Commissioner: Note the objection of counsel for the defendants.

A. My conclusions are that the conclusions which Mr. Johnson reached, that simply because the dye did or did not reach the surface in the case of his experiments, he therefore concluded that the sewage would not reach the surface, my belief is that that conclusion is unfounded and is without any validity for the reasons stated by me in the first part of my questions, namely, that the velocity of discharge was different in the case of Mr. Johnson's experiment, than in the case of the sewage discharge; secondly that the direction of discharge is different in the case of Mr. Johnson's discharge and in the sewage discharge; and since I have shown that both these contribute to the question of appearance of dye on the surface of water, I feel warranted in believing that no conclusion could be drawn concerning the appearance of sewage on the surface of the bay from Mr. Johnson's series of dye experiments as to the appearance of that dye on the surface of the bay.

Q. Since you testified on direct in the Complainants' case originally, have you made any further inspections of the harbor conditions to determine the problems of diffusion of sewage with waters in the harbors and streams and if so, state where.

4236

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. I have. I have made some additional inspecitons in New York Harbor, also on the Albany water front, also in the Troy water front, also in Schenectady at the discharge of the sewers into the Mohawk River, also from the City Ottawa into the Ottawa River and into the Rideau River and Canal, also into Prescott water front from the City of Prescott, Ontario, into the St. Lawrence; also from the City of Kingston into Lake Ontario; also from the City of Toronto into Toronto Harbor, which is a part of Lake Ontario, also from Niagara Falls into the Niagara River; also into the Niagara River from the City of Buffalo; also in Tonawanda Creek, from the Village of Batavia; also from Rochester into the Genessee River; also from Syracuse into Onondago Creek and the upper end of Onondago Lake. These inspections which were all in fresh water, were specially made for the purpose of observing the influence of quietude of the water into which the discharge was made as affecting the rate of diffusion; and I can give the details of these observations, if you wish, but in general they indicated very definitely and positively that the rate of diffusion depended in almost sole measure on the agitation or motion of the water into which the discharge of sewage was made.

Q. Professor Landreth, has your attention been directed to the testimony given by General Robert, an expert witness called on behalf of the defendants in this suit?

A. It has.

Q. Directing your attention now to Complainants' Exhibit No. 135, to the plant described on pages 1 and 2, and page 3, and then directing your particular attention to the second paragraph on page 3, marked with the figure "2" which states there will be
4237 absence of deposits—I ask you whether or not in your opinion this effluent produced by such a plant, will or will not leave deposits that may obstruct navigation?

Mr. Riker: The question is objected to as not being rebuttal, also on the ground that there is no testimony of any kind of any obstruction to navigation; there is nothing in the stipulation that it is obstructing navigation.

The Commissioner: Note the objection of Counsel for the defendants.

A. Basing my answer on the testimony of General Robert, I should say it would produce deposits objectionable on the bottom of the Harbor. While General Robert's answer related to the production of deposits in Newark Bay, and this plant is proposed to discharge into New York Bay, I fail to see wherein the discharge of an amount of deposits represented by General Robert, will be lacking in harmfulness in New York Bay, if the volume equals the amount indicated by the General for Newark Bay. I assume, of course, that in New York Bay the deposits would be scattered over doubtless a somewhat larger area, but while that difference would produce a helpful influence so far as the time when they become objectionable is concerned, on the other hand, they would produce a harmful difference as to the area of the Bay affected. In other words, the date when the objection will become visible as serious would be delayed in New York Bay as compared with Newark Bay, but the area covered would be extended and very much larger.

Q. Is there any peculiarity in conformation of New York Upper Bay in its main Ship Channel that would support the views you have expressed?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

A. Yes, sir.

Q. Will you state what they are Professor Landreth?

Mr. Riker: The same objection.

The Commissioner: Note the objection.

4238 A. The point proposed for the place of discharge of the Passaic Valley Trunk Sewer outlet is on the westerly slope of the Main Ship Channel in a depth of water approximately 40 feet and just above Robbins Reef. Below that point there are several ridges, which run across the channel which ridges, in each case, tend to form barriers, which would prevent the deposits from passing out to sea. There is one that is very close to the point of discharge. There are other smaller ones within a mile or so, and the main bar through which Ambrose Channel passes forms another and the highest of all. The influence of these bars will be to pre-

vent these deposits from escaping out to sea, even though portions of them shall be more or less moveable; they will move back and forth and will not go out to sea. I do not wish to imply that all of this deposit would be movable, a large proportion, the greater part of the mineral deposits would be thoroughly stable; once they reached the bottom they would stay there. But with that mineral deposit, there would be some organic deposit and that would be of lighter density and would tend to make certain portions of that material partially flocculent and movable so as to be moved by currents, at least until the organic matter had become separated from it by decomposition, leaving the mineral on the bottom. Now, observations in the bottom of the harbor show that this movement takes place, but they also show as indicated by the government dredgings preparatory to the cutting of Ambrose Channel, that those deposits never cross the bar; they are caught by the inner surface of the bar and are prevented from passing out. Now the tidal velocity over the bar is less than it is in any of these other sections. Therefore if the slope of the tidal bar is sufficient to prevent those, then the other bars will tend to prevent them, because they are not so strongly affected by tidal movements. The result will be that a discharge of mineral matter will go pretty rapidly to the bottom, not at one spot, but it will be deposited, and not very far removed from the individual outlets; the discharge
4239 of organic matter on the bottom will scatter somewhat more, but that in no case will even the most movable portions escape out to sea. The results therefore will be that they will tend to accumulate in the harbor; the mineral matters will never be decomposed, they will be constantly accumulating. The organic matters will be subject to decomposition and they will remain there until the different constituents have become decomposed. Now, there are certain constituents of sewage which are very rapidly decomposed, and there are certain other constituents which are very slowly decomposed. I am referring now to mineral deposits, and there are certain other deposits which occupy all the ranges between those two extremes, such material as cellulose and material such as hair and leather, and most fibrous materials, are among the — of those contained in sewage to be decomposed Such material as animal flesh is most rapidly decomposed—vegetable tissue occupies a middle ground between the two; but there is sufficient volume on all sewage of these organic materials to produce an accumulation of undecomposed organic matter on the bottom. This is entirely in addition to the mineral matter on the bottom, which always accumulates and never suffers any decomposition whatever. My conclusion, therefore, is that, given the same discharge into New York Bay as predicted by General Robert for Newark Bay, that the difference will be that the accumulation will occur in more extended areas, but of lesser depths, but that in no case will the material escape out to sea.

Q. Directing your attention again, Professor Landreth, to Complainants' Exhibit No. 135, I ask if that exhibit discloses the area to be covered by the multiple outlets, and also gives the depth below

the surface of the water at which those multiple outlets will be erected, and as to whether or not in your opinion, the area and the depth below the surface of the water will in itself be an obstruction to navigation, and impair the use of the Main Ship Channel for shipping interests, docking in the City of New York.

Mr. Riker: Same objection and the further objection that
4240 the instrument speaks for itself; and the further objection that it is entirely in the jurisdiction of the United States Government.

The Commissioner: Note the objection of Counsel for the Defendants.

A. In my opinion there will be a dangerous influence and a menace to navigation even without the effect of the accumulation of deposits The water at the point of discharge has a depth of about 40 feet. It has an area as given by the dimensions in the specifications of approximately 3½ acres. We are already needing the drafts of upwards of 30 feet. In fact depths between 35 and 40 feet are imminent and we are likely to have them very soon. Those are not exceptional amounts in depth of draft; they are not spasmodic changes of draft, but they represent progressive changes in the draft of vessels, which have been going on for nearly a hundred years. They have been climbing up in size and not only in length but breadth of beam, and necessarily in draft, because the most economical form of ship has a certain relation between the length, the beam and the draft, and as the length and beam increases, the draft also increases, everything tends towards larger and larger units. That is true not only of water communication but of rail communication. Economy rests in moving large units and that is just as pronounced in water units in the hulls of ships as in trains. It has been going on and there is no reason to suppose it is going to stop now. We have already reached a draft of from 35 to 40 feet in depth; it is only in my opinion a matter of a few years before we shall reach a draft of upwards of 40 feet and even if we have a full available depth of 40 feet, it is only a matter of a short time before the outlets of this present sewer as now planned and as now approved by the War Department will be not only a menace, but a bar to navigation across that area, 3½ acres in extent, right in the Ship Channel of the harbor, the only part of the channel that can be occupied by deep ships. The profile shown in
Exibit No. 205, the Complainants' exhibit, shows that there
4241 is not a foot of territory on the west of that point anywhere to the Bayonne shore line where a draft of as much as 15 feet at that point can be found. There is only a narrow channel where 40 feet can be obtained, and to limit the usability of that channel by this construction would, in my opinion, be not only a menace, but an absolute bar to navigation for that portion. The draft of vessels as indicated by their registry is not the only dimension which is important to consider in the feasibility of harbor channels. The drafts are always recorded when the ship is in dock lying quietly; they are measured then and are recorded then not only the length of the load line, but the beam and the draft are recorded

when the ship is lying in the dock quiescent; but when the ship is over this disposal area, it will not be standing still, it will be moving and it will be moving at a pretty decent speed and it is a well established fact in navigation that when a ship moves in a channel which is at all restricted in either depth or width, that the motion of the ship causes a settling of the ship into the water called "squatting," and that the amount of that "squatting" in the water lowers the vessel. This, from well known and well understood causes comes from the fact that as the ship moves through the water the water must move past the ship; if it moves past the ship in a restricted channel, it must move at a considerable velocity, as it moves with velocity its energy is changed from pressure into motion and it is therefore no longer able to bear the ship as strongly upward as it was when it is standing quiet. Consequently the ship settles. The amount of that "squatting" is a function of the velocity of the water passing under the ship and that in turn is a function of the speed of the ship and the depth remaining, between the bottom of the ship and the bottom of the harbor; if that is narrow; the water will rush rapidly and the squatting will be greater, but it does not occur to any appreciable extent in the deep sea, at least not to so great an extent as it occurs in narrow channels. That fact is so well established that in the design of Canal prisms, as in
4242 the enlargement of the Erie Canal and in the construction of the Barge Canal, that factor was a strong element in the determination of the depth to be provided. Now, this squatting is liable to amount to several feet, depending on the remaining depth between the bottom of the vessel and the bottom of the harbor. It may be two, three or perhaps even four feet. Therefore the bottom of the keel for a vessel drawing 36 feet would not be 36 feet below the surface of the water, but 36 feet plus the depth of its squatting, so that that depth must be taken just as arbitrarily and just as rigidly into account as the depth of the keel itself when the ship is lying in the dock, and must be added to that depth.

Q. Assuming a ship like the "Imperator" which left for Europe yesterday drew 38½ feet of water at the dock, how many more feet would you add as necessary for the squatting that you have described?

Mr. Riker: Counsel for the Defendants asks Counsel for the Complainants to indicate to what testimony this question is directed as rebuttal.

Dr. O'Sullivan: This testimony is directed in rebuttal to that portion of Mr. Johnson's testimony in which he took Complainants' Exhibit No. 135 and on page 30, testified from that exhibit that there would be no impairment to the navigability of the New York Upper Bay.

Mr. Riker: Well, the attention of the witness is then directed to the specific testimony, as the recollection of counsel is that there is no such testimony by Mr. Johnson, and the question is therefore objected to on the ground that it is not rebuttal, but it is an attempt to introduce into this case, a new issue not made by the pleadings, and is also an attempt to introduce an issue which involves the sovereign jurisdiction of the United States Government.

Mr. O'Sullivan: The question is pressed by Complainants' Counsel for the reason that the obstruction to navigation in the Main Ship Channel in New York Upper Bay would impair the property
4243 rights and the property interests of New York City and of New York State.

Mr. Riker: Counsel for the defense rejoins to that suggestion as to the reason for pressing the question, that if the United States Government sees fit to close up the whole of the channel, it is within its sovereign power to do so, and that therefore this question is not only incompetent and irrelevant, but it is impertinent.

Mr. O'Sullivan: Counsel for Complainants in reply to that will state affirmatively that the function of the Secretary of War therein is to preserve the navigability of navigable channels and bodies of water and not to exclude shipping from their use,—not to close them up to navigation.

Mr. Riker: Counsel for the defense again rejoins that the permit of the Secretary of War is already in evidence in this case and permits the erection of this particular structure in the harbor of New York, upon the terms that are indicated in the stipulation, and that his judgment is supreme.

Mr. O'Sullivan: In re-ly to that comment of Counsel for the defense, Counsel for Complainants answers that the second condition in that permit shows the revo*k*ability of the permit and that the moment that the structure to be erected under the permit becomes an obstruction to navigation, that the Secretary of War has reserved to himself the right to revoke the permit.

Mr. Riker: Counsel again rejoins that that answers the whole objection and enforces the proposition, that this testimony is entirely irrelevant, as the United States Government, as the supreme power, has the power and the right to change the location of these outlets or to remove them if it sees fit.

Mr. O'Sullivan: Complainants' Counsel still presses this question for the reason that it shows that now the property interests and the property rights of the State of New York and of the City of
4244 New York are threatened by this structure about to be erected under this permit.

Mr. Riker: Counsel for the defense again rejoins that those objections should be presented to the Secretary of War and that they are not questions for this Court to deal with.

Mr. O'Sullivan: And in re-ly to that Counsel for Complainants wishes to assure Counsel for Defendants that they have already been submitted to the Secretary of War and are now under consideration by that official.

Mr. Riker: Then Counsel for the defense objects that it becomes still more evident that this question is not only irrelevant but impertinent.

(The stenographer read the question as follows):

Q. "Assuming a ship like the "Imperator" which left for Europe yesterday drew 38½ feet of water at the dock, how many more feet would you add as necessary for the "squatting" that you have described?"

A. In answer I wish to say that I have not made a close study of the form of the lines of the hull of the Imperator and neither do I know the speed at which she actually would pass out of the harbor, both of which elements are essential; but assuming the general form of hulls followed by the company by which this ship is owned, and assuming a speed of 10 knots per hour, I should say that the "squatting" would amount at least to a foot and a half or two feet, but I don't believe it proper to allow a construction to be erected in the harbor which shall be at the same distance below the surface of the water as the bottom of the hull is below the surface of the water. I do not believe in other words, you can afford to rub the keel on the obstruction just stated and that a leeway between the keel, even when the ship is under the influence of "squatting," and the bottom of the harbor is also a well recognized necessity in harbor construction and in canal construction and in lock construction, and in dock construction, and the margin of a foot is the least that is ever considered as coming between those two, even ignoring the question of the increased motive power necessary to move the ship under "squatting," due to
4245 the fact that the ship is all the time climbing up a steep grade, all the time propelling itself out of a depression up the side of a slope, which very materially increases the motive power, and thoroughly apart from that and purely on the basis of safety against accident from contact between the ship and the bottom a margin of at least one foot is always considered essential in the design of locks and docks and basins and the like, and still more in harbors where the conditions are not subject to as close predetermination, so that if the Imperator draws 38½ feet in the dock, I should now consider that such a construction if built today would be an obstruction to navigation to that ship.

Mr. O'Sullivan: That is all.

Cross-examination by Mr. Riker:

Q. Professor, what is the depth of the water in the Ambrose Channel at mean low tide?

A. It is approximately 40 feet.

Q. The ships pass through the Ambrose Channel, do they?

A. I think she did.

Q. Is that the main entrance into New York Harbor, into New York Bay at the present time?

A. It is the most direct; it is not the only one.

Q. Is it the best one?

A. It is the best one for ships whose drafts permit them to come that way, because it represents a material saving in distance.

Q. Where did you understand these outlets to be located with reference to the bottom of the Bay?

A. I understand they are located at or slightly above the actual surface of the bottom of the bay where they are placed.

Q. Why do you say that?

A. I say that because I do not wish to be unfair to the defendants by assuming that they project up into the Bay; I have not assumed that they do.

Q. Well, do you know anything about it; I am not asking you what you assume, I am asking you what you know about it?

A. I know that they were either to be made at the surface
4246 of the Bay or project up into the water way; they cannot go below the surface of the bay.

Q. They will either be on the surface or project up; now which are they to be?

A. I have assumed that they would be on the surface.

Q. Then you are objecting to the surface of the floor of the Bay, aren't you?

A. Yes.

Q. You don't think that is deep enough?

A. I think that can readily be dredged deep enough, if it is not.

Q. Can the outlets of the sewer be readily put down to the increased depth?

A. No, sir.

Q. Why not?

A. If they are built, they cannot be lowered.

Q. Will you tell us why they cannot be lowered after they are built?

A. Not without reconstruction, not without the expenditure of large amounts of money, and not without interrupting the discharge.

Q. Well, do you think the bottom of the Bay can be deepened without expenditures of large sums of money?

A. Comparatively, yes.

Q. I am not speaking comparatively; I am asking you whether the dredging of the bottom of the harbor requires the expenditure of a large amount of money in your judgment?

A. The relative cost of excavating the harbor of 3½ acres would be very slight, insignificant almost, compared with the expense of lowering the structure for the discharge of the sewage.

Q. You don't mean to be understood that you think it is not a possible thing to lower these outlets if the depth is increased?

A. It is not an impossible thing; it is not impossible to discharge this effluent into the Passaic River for that matter.

Q. I did not ask you that question; you need not volunteer anything. Answer the questions without interpolating your own suggestions and I will be obliged to you.

A. I will withdraw that part of my answer, Mr. Riker.

Q. How deep is the Ship Canal at the point of discharge, the greatest depth?

A. The Ship Canal?

4247 Q. Yes.

A. What canal have you reference to?

Q. The Ship Channel, I mean, at Robbins Reef?

A. Well, at the point of discharge it is 40 feet.

Q. Well, immediately outside of the point of discharge, how deep was it?

A. By "outside" do you mean out towards sea?

Q. Out towards the center of the Ship Channel?

A. It reaches a depth of about 65 feet.

Q. How wide is it with that depth?

A. It is very narrow indeed.

Q. How wide?

A. Well, just one foot so to speak; it runs down to that point there. If you take a point above the bottom, I can give you the width.

Q. Well take it at 50 feet in depth; how wide is the Ship Channel?

A. At a depth of 50 feet the Channel is about 2,000 feet wide.

Q. And this area of the outlets of the Passaic Valley sewer is on the side wall of the Channel, isn't it?

A. Well, there is no wall there; it is on the side slope.

Q. On the side slope?

A. Yes, sir.

Q. Is it your conscientious belief, Professor Landreth, that the insertion of these outlets on the surface of the slope of the Ship Channel at a depth of 50 feet for a width of 2,000 feet is going to interfere with the navigation of New York Bay at that point?

A. It is.

Q. How?

A. By the fact that the large volume of tonnage coming in and out of the harbor makes it impracticable for each ship to select its own lane or line, and to adhere to that; it has to have a certain amount of leeway laterally across the channel, and it would mean if this obstruction is allowed to continue, allowed to be produced there, that ships of this draft would have to avoid that, would have to be kept clear of that area; would have to have a system of buoys there and depth markers for ships of different drafts. It would be greatly confusing and they would in themselves cause interference with navigation.

Q. How much additional width do you think there would be in the ship channel if these outlets are not placed there of a
4248 depth of 40 feet?

A. I can give you the width.

Q. Do you understand my question to be hoe much in width the location of these outlets as proposed are going to decrease in your judgment, the available steerage rooms of ships in the channel?

A. Why, with the attendant works, it would diminish the width by several hundred feet.

Q. What do you mean by the attendant works?

A. I mean the construction supplementary to the discharge of the sewage through the outlets.

Q. What are they?

A. In the first place, the main tunnel itself; in the second place, any gate house construction, and outlet or shaft house construction that may be built there; and in the third place, the very outlets themselves and the area which they cover. The plans offered are not sufficiently in detail to show the width and the detail of those supplementary portions, but I am taking the area as 3½ acres and taking the dimensions of that dispersion field as indicated, and then taking the necessary inevitable supplementary works when I say there will be several hundred feet additional width which would be impaired, and as far as the channel goes that would extend all the way to the west shore.

Q. Do you think the tunnel is going to interfere with navigation?
A. Not unless it is kept up to somewhere near the depth at which the outlets are given.
Q. Well, the tunnel in itself how is that going to interfere with navigation?
A. The depth of the tunnel in itself and its covering will interfere with navigation, just in proportion with the depth of the top of it below mean low tide.
Q. You understand that a tunnel is something that is covered over with artificial means?
A. Well, it depends on how you construct and operate it; besides if it has a gate, or has a tube tunnel, it must have a shaft; the shaft must have protecting works around it.
Q. I am asking you about a tunnel, I wish you would not get away from that. I am asking you about a tunnel and I want to know how you think a tunnel under New York Bay is going
4249 to impede navigation?
A. A tunnel under New York Bay would impede navigation if the future needs or present needs demand dredging, which would be interfered with by that tunnel, and in no other way except so far as the supplemental works of shaft house and permanent gate house may be concerned.
Q. So that as to the present conditions, you don't mean to be understood as saying that a tunnel will interfere with navigation, do you, in itself?
A. A tunnel in itself will not interfere with navigation as the harbor bottom is today, but I have added supplemental works which are tied up with the tunnel and cannot be separated from it.
Q. I want to know what supplemental works you are testifying to as interfering with navigation?
A. I am testifying to the two supplemental features that go along with the tunnel, namely, the shaft house, one or more, which must be built there, and the construction and filling around it, and so on; secondly with the rendering impossible of the dredging of the harbor, lower than the top of the tunnel, those two are two features which are inseparable from the tunnel itself.
Q. Now, where is the shaft house to be located, do you know?
A. I don't know; there must be a shaft house there.
Q. Do you think that is going to be located in the Ship Channel?
A. I cannot say where that will be located.
Q. Well, do you think it is going to be?
A. I think it very likely will.
Q. In the Ship Channel?
A. At or near the point of entry of the sewage into the discharge mains.
Q. Now, how far is that from the Channel?
A. That is part of the Channel.
Q. It is in the Ship Channel in your judgment?
A. Yes.
Q. That the shaft house is to be located?
A. Yes.

Q. Do you think they will build a shaft house in a depth of water of 44 feet?

A. Your question did not ask that; your question asked me where the point of beginning of the dispersion area was, and that
4250 is in the Ship Channel.

Q. I asked you where you thought the shaft house was to be located; you don't hear very well, Professor, I am afraid?

A. Yes, I hear first rate.

Q. That is the question, and I refer you to the record; I want to know where the shaft house will be located?

A. I told you I did not know, but I thought it would be near the point where the sewage leaves the tunnel.

Q. Now, I ask you whether you think the shaft house will be located in the channel?

A. I think the shaft house may be located there.

Q. Near the edge of the channel but not necessarily in the deepest part of the channel, of course; you don't know anything about it as a matter of fact, do you?

A. I don't know anything about what you people actually will do, no.

Q. Now, you said in your opinion the discharge from the sewer outlets will be vertical, didn't you?

A. Yes.

Q. You told others that that was your opinion?

A. I said vertical or horizontal.

Q. Well, didn't you say that you thought it would be vertical?

A. If you read the answer I think that you will find that I said vertical or horizontal.

Q. Well, what do you think it will be?

A. I think it will be vertical or horizontal as I answered before.

Q. Why do you think it will be vertical?

A. From some indications which I have had that that is the nature of the outlet; I have seen two outlets proposed by your people, one to consist of a pair of horizontal outlets; in other words, a vertical T capped with a pair of horizontal outlets, and another style of outlets, a vertical nozzle, ostensibly an inverted conical nozzle, giving a so-called spiral movement. I cannot say which of those two outlets you people are going to adopt, and I don't attempt to say, because I do not know. I do know you would not point them downward, as in Johnson's experiments; I know you have too much sense for that.

4251 Q. I am not asking you for that or the sense of it; I want to know your reason for saying that you think the outlets of the discharge may be vertical, and you have given it, and I now direct your attention to the stipulation which is Complainants' Exhibit No. 135, from which I will read: (Reading) On each of these vertical T's shall be placed outlets arranged to discharge horizontally across the tidal current"?

A. Yes.

Q. Now, having that before you, do you mean to say that you think the discharge may be vertical?

A. I have also before the fact——

Q. Will you answer the question?

A. Yes, I will answer it, but I will have to answer it in my own way or not at all.

Q. Then don't answer it all unless directly?

A. That does not lead me to conclude that the discharge will be horizontal.

Q. You make a distinction between the outlets and the discharge, do you?

A. No. I will go farther in saying that I don't conclude that the outlets will be horizontal in spite of the fact that that plan, which you are permitted to depart from, says so.

Q. Where are we permitted to depart from it except——

A. In the clause following; in the article or paragraph following that, you are permitted to follow that plan or other lawful plans.

Q. That is your interpretation of it, is it?

A. Yes, sir, Mr. Riker.

Q. Is it not your understanding that the plans must be approved by the Secretary of War?

A. I assume they must, yes, sir.

Q. And you think then that this stipulation which has been entered into by the State of New Jersey with the United States of America does not indicate any fixed plan at all; is that your understanding of it?

A. No.

Q. Well, then, do you understand that it provides for a horizontal discharge?

A. No.

Q. You do not?

A. No.

Q. It says so, doesn't it?

A. No.

Q. I read it again; (Reading) "On each of these vertical
4252 T's shall be placed outlets arranged to discharge horizontally across the tidal current." Does that mean what it says or doesn't it?

A. I have read it several times.

Q. What do you understand that means?

A. I cannot answer it except in my own way.

Q. Answer it in your own way; what do those words mean?

A. Not only your people have planned this one, but also a different one in which the discharge is vertical and that the agreement with the Government permits you to depart from either one of these, so long as it is not unlawful; and under that I believe that you will discharge vertically upward; you may discharge downward, but I don't think you will.

Q. I ask you what you understand the words I have read to mean; whether they mean horizontal discharge or not?

A. Those words there clearly mean horizontal discharge, but you are not bound to follow those.

Q. And you extend that opinion to the whole of this policy do

you, that we are at liberty to change them as we see fit; is that your understanding of the stipulation?

A. No, oh, no.

Q. Then why do you say we are at liberty to change this part of the stipulation?

A. You are at liberty to change this within lawful limits.

Q. To reach certain definite results?

A. Yes.

Q. And you think we can reach those certain definite results if we discharge the sewage vertically?

A. I do not.

Q. Then you think we have a right to change the direction of the discharge, do you?

A. I do.

Q. Have you made any dye experiments, color experiments, in the harbor of New York?

A. No, sir.

Q. Where did you make your experiments?

A. At Union College Engineering Laboratory, Schenectady.

Q. You think that those conditions are parallel to the conditions in New York Bay?

A. Not entirely, but the things which I studied are just
4253 the same in New York Bay as they are in Schenectady or Toronto.

Q. Why didn't you make your experiments as Mr. Johnson *sic*, in New York Bay?

A. Because it was not possible to make the observations of the same degree of refinement and to govern conditions as closely as it was in the laboratory where we can control everything except the thing which we wish to study; as I tried to make clear on my direct examination. I was trying to study the single element of the effect of velocity on a jet, whether a high velocity or a low velocity, and I studied that and kept everything else constant. Then having finished that, I desired to study the effect of direction of discharge and keep everything else constant; it would not have been possible to do that in New York Harbor, and it was possible in the laboratory in large sized experiments, and since the application of these laws are fixed and immutable and apply just as well in New York Harbor as in the engineering laboratory at Union College, I am safe in the conclusion that when I discovered that the effect of velocity has a certain result in the laboratory it will have the same effect in New York Harbor so far as the qualitative results go; I do not claim the same as to the quantitative results.

Q. You do not doubt the experiments conducted by Mr. Johnson were conducted as he described?

A. I do not doubt that at all; I have assumed that they were.

Q. And the results were as he described them?

A. I assumed so, exactly as he described them.

Q. Do you assume so?

A. I assume so.

Q. Do your own laboratory experiments coincide with the results that he attained from his experiments as he described them?

A. While I do not differ with Mr. Johnson as to the methods of his procedure, I do differ from his conclusions which he drew from them.

Q. I did not ask you for a conclusion; I am asking you for the results?

A. My results? Mr. Johnson did not testify to results; he testified to conclusions.

4254 Q. He didn't testify to results?

A. Unless you take the appearance or non-appearance of liquid as a result, and in that mine agreed with his substantially.

Q. Isn't that a result?

A. Well, if you wish to call that a result.

Q. Don't you call it a result?

A. I will call it a result to satisfy you, and in that they agreed substantially with Mr. Johnson.

Q. At what depth did Mr. Johnson discharge the colored water?

A. 10, 20, 30 and 40 feet in depth.

Q. Does it make any difference in your judgment at what depth the colored water is discharged as to its appearance on the surface?

A. Certainly.

Q. At what rate of vertical discharge at the rate Mr. Johnson testified he discharged the colored water would the result be equivalent in your judgment to the same discharge in quantity and horizontally at a depth of 4 feet?

A. I don't understand the question.

Mr. Riker: Read the question.

The stenographer thereupon read the question.

The Witness: Well, I still must admit I cannot understand the question, when you ask detailed conclusions from it.

Q. You don't understand the question?

A. I do not.

Q. I still press the question as perfectly clear?

Mr. O'Sullivan: I now object to the question on the ground of ambiguity; it is clearly a conflict in terms.

Mr. Riker: I press the question as perfectly clear and understandable; if this witness cannot answer it, it is because he cannot.

The Witness: I am sincere in my wish to answer it; if you will try to alter the wording, I may answer it.

Q. It is so simple in its terms I do not believe I can make it any simpler?

A. Then I am so stupid I cannot comprehend it.

4255 Q. Do you understand that the discharge from the Passaic Valley Sewerage Commissioners' sewer is correctly described in Complainants' Exhibit No. 135?

A. I assume that one possible plan of discharge is described accurately there, yes, sir.

Q. But not the results to be obtained in New York Bay from the discharge of the effluent?

A. I do not believe the results will be obtained, no, sir.

Q. And you do not believe that they propose to produce those results in New York Bay?

A. I do not understand what is meant by the word "propose"; I have no question as to their sincerity in desiring to obtain them.

Q. Well, do you doubt that they have agreed to obtain them?

A. No.

Q. Do you doubt that they intend to obtain them?

A. No.

Q. But you doubt that they will carry their intention into effect?

A. I doubt their ability to obtain the results that are indicated and to make possible the determination as to whether they have obtained them or not.

Q. You mean that the results that are guaranteed are impossible of determining as to whether or not they are produced?

A. I mean the form in which the results are stipulated are ambiguous.

Q. They are equally ambiguous in connection with the Bronx Valley Sewer?

A. So far as the two agreements are parallel, they are.

Q. Don't you know that they are identical so far as the results are concerned?

A. They are for a certain term of years.

Q. Well, the results as described, are they or are they not identical?

A. They are not identical in another respect, also that whereas in the Passaic Valley Sewer agreement with the Government there is no provision for means of ascertainment other than is carried by the words themselves, left to ordinary determination; in the Bronx Valley agreement a specific means is provided by which these compliances shall be ascertained and the results interpreted, also in the Bronx Valley agreement, the agreement which is imported from the
4256 Passaic Valley is limited to a certain term of years, at the termination of which time the entire agreement may be altered and the terms changed.

Q. I ask you again whether the guaranteed results as contained in the Bronx Valley stipulation are not identical with the guaranteed results contained in the stipulation which is Complainants' Exhibit No. 135?

A. With the few important exceptions that I have just mentioned, they are.

Q. Do you think that the results in the one case can be determined, and cannot in the other?

A. Yes.

Q. Which ones can be determined in the one case, but cannot be in the other?

A. In the Bronx Valley case a very definite system of verification is provided for in which discretion is left to the arbitrators or Board of Inquiry to ascertain substantial compliance, while no provision for interpretation is made in your agreement.

Q. What is that provision that you refer to?

A. It is the provision by which either party may invoke a Board of Inquiry—I have forgotten just the name employed for it—

to determine the question of the compliance with the agreement and to determine what needed modifications or changes of plan may be essential or necessary. Even if the first one had not been included, the fact that the power of providing for modifications in the agreement is there, would make it possible to cure the defect even if this Board did not have the power of interpretation.

Q. You seem to misunderstand my questions frequently; our minds do not work the same. The definite provision is what I want you to say, that you think is contained in the Bronx Valley stipulation and not in this; the definite standard provision that is so ascertainable.

A. I had it in mind and answered it as far as I am able to by memory and you asked for an explicit understanding and I——

Q. I was trying to get you to — what I supposed you had in mind, the 10 per cent. reduction in putrescibility; is there
4257 any other definite standard than this?

A. I am not referring to that at all.

Q. You are not referring to that at all?

A. I am referring to two other points of difference.

Q. What are the two other points of difference as to the results guaranteed?

A. The two other points of difference are those which I have mentioned twice.

Q. Just mention them again, briefly, if you can?

A. The first is that there is a term of years over which this shall remain in force; the second is that there is a provision for a Board of Inquiry—I am in doubt as to the name given to that—that is one of the things I am trying to verify,—by which recommendations for changes of those agreements may be provided.

Q. I am asking you, however, or trying to ask you, in regard to guaranteed results; you don't call those results, do you? What I want to know is what guaranteed results are in the Bronx Valley stipulation more definite and more easily ascertained than in the Passaic Valley stipulation; I am not asking you for provisions for changes at all, I am asking you for the instrument as it stands with reference to the guaranteed results, which are more easily ascertained in the Bronx Valley than in the Passaic Valley stipulation?

A. There is this additional, which is a third point of difference——

Q. I did not ask you as to the point of difference; confine yourself to what I ask you?

A. The third point relates to just what you are asking about, the greater precision with which the results are to be stated.

Q. Now, what is that?

A. This agreement recites as follows: "The Bronx Valley Sewer Commissioners at once will begin the installation of the plant for the special purification of the effluent of the Bronx Valley Sewer system, by screening and sedimentation with an efficiency sufficient to remove and which shall at all times remove from said effluent enough of its putrescible contents to purify the same to
4258 the extent of 10 per cent. upon an absolute putrescibility scale."

Q. Now, that you think is more definite, do you?

A. Yes.

Q. Do you agree with those witnesses who have testified that the works as described specifically in the Passaic Valley stipulation will reduce at least 10 per cent. the putrescible matter in the sewage?

A. I think I do not.

Q. You think you do not?

A. Yes.

Q. Well, have you calculated how much they will reduce the putrescible matter?

A. I have not.

Q. Then why do you guess about it at all, if you do not know?

A. I estimate and believe that they will not do so, because of the conditions under which the putrescible material is sought to be removed in the Passaic Valley Treatment Works; I don't believe that they will remove the amount indicated as required to be romoved in the Bronx Valley stipulations.

Q. If witnesses went on one after another for the Complainants in this case, and testified upon examination and cross examination that the works as described will remove at least 10 per cent. of the putrescible matter, you do not agree with them, is that it?

A. If all witnesses were unanimous in saying that it would, I should begin to doubt my belief and opinion, if they were reputable and authoritative witnesses.

Q. As to all other features of the two stipulations, do you think that the Bronx Valley is more specific than the Passaic Valley, or the contrary?

A. Insofar as relates to the stipulations which are common to the two, there is no difference; the one copies the words of the other virtually.

Q. Well, now those things, that are in common and copied one from the other, do you think that in the one case they would be more easily ascertained than in the other?

A. I do.

Q. Why?

A. For the very reason that I have stated once before, that
4259 during the first period of years provided for, the Bronx Valley has this additional standard by which to test the accomplishment of the results and at the end of that period the Bronx Valley has the power to provide for an entire alteration and revision of that set of specifications.

Q. Then you think that the removal of 10 per cent. of putrescible matter on an absolute putrescibility scale will result in the case of the Bronx Valley Sewer in the results which are guaranteed in that stipulation do you?

A. I have not stated that at all, nor any approach to it, and there is no opportunity for doing that, because I have not seen the plans by which that 10 per cent. is proposed to be reduced.

Q. You know that the State of New York and the Bronx Valley Commissioners have agreed to produce the same guaranteed results that the State of New Jersey and the Passaic Valley Sewerage Commissioners have agreed to produce, don't you?

A. I do, and if you wish the answer in this form, I will say I believe it can be done and I believe the Bronx Valley people will do it.

Q. I ask you whether or not you believe the removal of 10 per cent. of putrescible matter from the sewage of the Bronx Valley will produce the results that are guaranteed in the stipulation?

A. Well, I am in doubt about that question.

Q. Well, do you think the State of New York and the Bronx Valley sewerage Commissioners are sincere in their undertaking with the United States Government?

Mr. O'Sullivan: Objected to.

The Commissioner: Note the objection.

A. I do.

Q. Do you think they can do this and accomplish these results and the Passaic Valley Sewerage Commissioners cannot, do you?

A. I do not think they can legally do it any more rightfully than the Bronx Valley, but with the difference that they will be held up at the end of their time if they are not doing it, and there is no provision for holding up the Passaic Valley parties
4260 other than an absolute revocation of the permit after the plants are once in operation. In fact, as I have said before, the underlying obstacle and objection there is the non-determinability as to whether they are complying or accomplishing the results or not.

Q. You are critizing the form of the stipulation that has been entered into through the Attorney General of the United States, are you not; that is your present criticism, is it not?

A. I do not think I would put it quite in that form, no, sir.

Q. Well, isn't that the result of it; do you think the stipulation of the Passaic Valley Sewerage Commissioners should have contained same provision of that kind that is in the Bronx Valley Sewerage Commissioners' stipulation?

A. I do not hesitate to say that I think the agreement should have provided more determinable means for ascertaining the compliance than it contains at the present time. Now, I don't know who is at fault for that whether it was the Jersey authorities or the United States authorities; I do not attempt to criticize or even try to locate the cause.

Q. Now, Professor Landreth, taking the assumption that the removal of the 10 per cent. of the putrescible matter from the Bronx Valley Sewers does not accomplish the guaranteed results in the stipulation of the Bronx Valley Sewerage Commissioners, do you understand that they intend to make an effluent which will produce those results?

A. If the compliance with the 10 per cent. reduction does not accomplish the results, there will be no way to determine that fact in legal form, in a way to constitute proof, but that is saved and the harm from that is rendered impossible, by the fact that at the end of a certain period, that agreement no longer is in force and may be modified, consequently the harm would be of shorter duration; but if the 10 per cent compliance is accomplished, there is no way to ascertain whether the others are accomplished or not in my

belief, any more than there is in the New Jersey or Passaic
4261 Valley agreement, for all time, without any specific 10 per cent. standard.

Q. You think a nuisance can be produced without your being able to ascertain or prove it?

A. I think before you prove a nuisance on a man, you have got to prove he is the cause of it; you cannot indict him if his neighbors are likely to have been the real cause. You have got to prove it against a man himself and prove him to be the cause of it.

Q. That is so, but I ask you whether you think a nuisance can be produced without it being susceptible of ascertainment and proof as a nuisance?

A. Oh, no, I assume that it is possible, but the fact that a nuisance exists does not complete the indictment; it is necessary to determine who is the agent of that nuisance. That is what New Jersey has agreed not to be—not to be the cause of the nuisance; it does not agree to protect New York Harbor against its own pollution.

Q. The Bronx Valley Commissioners have undertaken the same thing with regard to the Bronx Valley sewer have they not?

A. Yes.

Q. And you think if the removal of that 10 per cent. does not in fact produce an effluent that is guaranteed that not being susceptible of proof, although it is an actual fact that the New York authorities will take advantage of that and not produce the results guaranteed?

A. I do not mean to say that, that the document itself as a contract would not be enforcible unless you show that after the 10 per cent. has been produced and if a nuisance were being produced, you could not determine whether it was produced by the Bronx Valley Sewer Main, by Manhattan, Jersey—or any of the other towns.

Q. In other words in your opinion, the whole part of the stipulation which deals with the guaranteed results are practically flim-flam and not intended to have any effect at all, or to be paid any attention to?

A. I think it is a good deal less flim-flam than the document or form of agreement between the United States and the State of New Jersey.

Q. Now, I am directing your attention specifically to the
4262 provision with regard to the guaranteed results; I ask you in your opinion in regard to the Bronx Valley Sewer agreement with the United States Government, whether this part of the agreement is practically without meaning?

A. No.

Q. Well, what do they mean; what do the words mean, do they mean what they say?

A. They mean that when the 10 per cent, reduction has been accomplished, that if they still afford a nuisance, that there is no way to ascertain it any more than there is in the New Jersey agreement.

Q. That is what the agreement means?

A. Yes, sir.

Q. It does not mean that if the 10 per cent. reduction does not

result in preventing a nuisance from the discharge that the Bronx Valley Sewerage Commissioners will add another means of purification, which will result in the guaranteed results?

A. That provision there is the same as it is in the Passaic Valley agreement.

Q. Will you answer my question?

A. I assume, of course, that if it can be proven to their satisfaction that the 10 per cent. having been complied with and that a nuisance still exists, I assume that they will go ahead and construct other additional and modified works to accomplish that; but I am saying that it is in my opinion impossible to determine that fact, and that therefore that relief is for the time being out of our reach and we must put up with that during the remainder of the term.

Q. Well, now, I ask you whether you think in your opinion, that at the point of discharge in the Passaic Valley Sewer, there will be sleek fields?

A. I do.

Q. You believe that?

A. I do.

Q. That there will be odors?

A. Yes.

Q. There will be floating particles of matter?

A. I don't think the odors will be serious, but I think there will be odors.

Q. Is there any difficulty in identifying the sleek fields with the discharge from the Passaic Valley Sewer as it exists?

A. Less difficulty in that than in others, but still more difficulty there.

4263 Q. Why?

A. There are other Brooklyn outlets which are not very far removed from that.

Q. How far removed?

A, Oh, I should have to scale off a map; I should say a mile or so.

Q. Any sleek fields extend out to Robbins Reef from those sewers at the present time?

A. I never have myself seen one.

Q. Well, you have been there a good many times, haven't you?

A. Yes.

Q. Any sleek fields from any sewers that you know of that extend to Robbins Reef at the present time?

A. I have seen sleek fields that extend opposite to that point; I don't think they have gone as far west as that point—any that I have seen.

Q. How near have you seen them determinable as a sleek field; how near to the point of proposed discharge?

A. I would not want to be explicit enough to answer that although I should like to; I should say that I have seen them certainly within half a mile.

Q. Now, if there is no sleek field developed over the point of discharge into the Passaic Valley sewer, do you think there is any dif-

ficulty of identifying it to the satisfaction of a court and jury that this is coming from the Passaic Valley?

A. There would not be if no one had seen a sleek field within half a mile, but I am providing for the fact that people may have seen it frequently.

Q. Have you ever heard of any sleek fields extending to Robbins Reef?

A. I have never asked one about that specifically, never directed the attention of any one specifically to that.

Q. How often have you been over the point of discharge of the Passaic Valley Sewer?

A. You mean over it, in the near proximity, the line of the boats?

Q. Near enough to observe the water?

A. Oh, I could not say certainly; 50 times probably 100 times.

Q. Seen any sleek fields there extending that far?

A. I have never seen sleek fields, I am sure, within a half mile of there.

Q. Do you think there is any danger of New York dis-
4264 charging more sewage, so as to extend their sleek fields into New Jersey?

A. I do not.

Q. Well where would you anticipate there would be any conflict between the sleek field produced by the Passaic Valley Sewer and any other sewer?

A. I am anticipating simply the legal difficulty of producing legal proof that sleek fields come from the Passaic Valley sewer, and I am appreciating the fact that if any one else has seen sleek field-there, caused by Brooklyn or produced there, before, that that would practically render it impossible of conclusive proof. That is the difficulty.

Q. You are taking a judicial attitude toward the quality of the proof, are you?

A. I am taking a common sense attitude.

Q. You are taking a common sense attitude are you, that where a sleek field never existed before, and has been produced immediately after the operation of a sewer discharge there, that that is not proof that a sleek field has come from the sewer?

A. You have incorrectly quoted my assumption.

Q. I have asked you to take that assumption.

A. Under that assumption it would be entirely proper to conclude that the sleek field was produced by the Passaic Valley, but that is not the condition I was supposing.

Q. What are the conditions you are supposing?

A. Conditions which I have stated were that I have not watched that field forever, have not seen it every day, and while I never have myself seen a sleek field within a certain distance, not more than half a mile away, I don't mean to conclude that therefore a sleek field never has and may not many times have reached over the point where the Passaic Valley Sewer proposes to discharge; I don't know what persons may be living today, who have seen that.

Q. Do you believe any such thing ever existed?

A. I don't know.

Q. I am asking your opinion; you are here as an expert witness, what is your opinion? Do you believe any such thing has ever existed?

4265 A. Taking the matter of probability, I do not believe the sleek field has ever, or at least as often, reached that point.

Q. Do you believe it has ever reached that point, as an expert?

A. I think it may have done so, yes, sir.

Q. That a visible sleek field has extended to the point of discharge within the State of New Jersey, caused by the sewage from New York?

A. I am saying it is possible.

Q. I am asking you whether you believe it ever existed?

A. My opinion is that it never has, but my opinion does not cover all possible proof.

Mr. Riker: That is all, Professor Landreth.

Redirect examination by Mr. O'Sullivan:

Q. Professor Landreth, directing your attention to the stipulation marked Complainants' Exhibit No. 135, I ask you what the date of the execution of that stipulation was?

A. April 14th, 1910.

Q. In Complainants' Exhibit No. 135 are the points of discharge described as being horizontal at these multiple outlets?

A. I think they are, yes, sir.

Q. Have you seen plans of the Passaic Valley Sewerage Commission by Mr. Harrison and Mr. Taylor, dated December 1910, in which the discharge points are vertical?

A. Yes, sir.

Q. Comparing the dates of this Complainants' Exhibit No. 135 with Complainants' Exhibit No. 177, which is the Bronx Valley Sewer stipulation, which is the more recent in point of time?

Mr. Riker: They speak for themselves; the question is objected to for the reason that the exhibits speak for themselves.

The Commissioner: Note the objection of Counsel for the Defendants.

A. The agreement with the Bronx Valley Sewer Commission is of more recent date.

Mr. O'Sullivan: I think that is all.

4266 Recross-examination by Mr. Riker:

Q. Do you know whether the designs which you have seen of Mr. Harrison and Mr. Taylor have ever been adopted by the Passaic Valley Sewerage Commissioners?

A. I have reason to believe that they have been, although I do not know.

Mr. Riker: That is all.

Mr. O'Sullivan: That is all.

Mr. O'Sullivan: The Complainants rest.

Adjourned sine die.

[End of Volume III.]

SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1916.

No. 3. Original.

THE PEOPLE OF THE STATE OF NEW YORK, COMPLAINANTS,

vs.

STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, DEFENDANTS.

VOLUME V.

INDEX.

		Page
Complainants' Exhibit	99—Statements of tests	3897
Complainants' Exhibits	100 to 107 (inclusive)—Maps	3976
Complainants' Exhibits	108 to 113 (inclusive)—Photographs	3984
Complainants' Exhibits	114 and 115—Diagrams	3987
Complainants' Exhibits	116 to 122 (inclusive)—Photographs	3989
Complainants' Exhibit	123—Map	3993
	124—Diagram of apparatus	3994
	127—Map of proposed Passaic Valley district sewer	3995
Complainants' Exhibits	128 to 134 (inclusive)—Diagrams showing test data	3996
Complainants' Exhibit	135—Stipulation to dismiss petition of intervention of United States, &c.	4005
	136—Report of Col. William M. Black, U. S. A., and Prof. E. B. Phelps as to location of sewer outlets, &c., March 23, 1911	4013

JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C.

		Page
Complainants' Exhibit	137—Report of James H. Fuertes, October 14, 1911, &c.	4179
	138—Diagram	4207
	139—Map of watershed of Susquehanna River, &c.	4208
	140—Statement showing condition of water at Harrisburg, Pennsylvania, in 1903	4209
	141—Statement showing color of turbidity of Susquehanna River at Harrisburg, Pennsylvania, in 1903	4210
	142—Map of Belfast Lough, Ireland	4211
	145—Report of Metropolitan Sewerage Commission, May 23, 1910	4213
	146—Report of Metropolitan Sewerage Commission July 25, 1910	4219
	147—Report of Metropolitan Sewerage Commission, September, 1911	4227
	148—Report of Metropolitan Sewerage Commission, November, 1911	4245
	149—Report of Metropolitan Sewerage Commission, December 2, 1911	4255
	149*a*—Map showing proposed sewer project	4264*a*
	149*b*—Map showing proposed sewer project	4264*b*
Complainants' Exhibits	150 to 156 (inclusive)—Maps	4265
Complainants' Exhibit	158—Report on estimate of Central Committee, February 6, 1912	4267
Complainants' Exhibits	159 to 169 (inclusive)—Diagrams	4313
Complainants' Exhibits	172 to 175 (inclusive)—Statements showing results of examination of mud	4314
Complainants' Exhibit	176—Statements showing results in Thames dredging	4315
	177—Motion by the United States to dismiss bill of complaint, &c	4317
	178—Report of observations of the pollution of harbors of the Atlantic seaboard, &c	4320
	179—Diagram	4365
	180—Statement	4365*a*
	181—Map	4366
	182—Report on sanitary inspection of shellfish grounds, &c	4367
	183—Directions for tests, &c	4417
Complainants' Exhibits	184 to 187 (inclusive)—Statements	4419
Complainants' Exhibits	188, 189, and 190—Report in the matter of results of bacteriological examinations, &c.	4423
Complainants' Exhibit	191—Diagram showing collection of samples of oysters from bed 490	4426
	193—Statement of temperatures, &c	4428
	194—Statements of comparative tests	4430
	195—Weekly report to Dr. H. D. Peasey, &c., June 20, 1910	4431

		Page
Complainants' Exhibit	196—Report of Lederle laboratories, September 16, 1912	4441
	197—Report of copper in oysters	4443
	198—Annual meteorological summary, 1912, with comparative data	4445
	199—"Disposal of sewage" (extracts)	4446
	200—Preliminary reports on the disposal of New York's sewage, July, 1912	4447
	201—Preliminary reports on the disposal of New York's sewage, September 1, 1912	4463
	202—Preliminary reports on the disposal of New York's sewage, February, 1913, &c.	4483
	203—Report of the commission introducing the reports of Messrs. Fowler and Watson, February, 1913	4543
	204—Report of observations of sewage disposal works, &c., September, 1911	4573
Complainants' Exhibits	205 to 214 (inclusive)—Maps and charts	4593
Complainants' Exhibit	215—Effect of salinity and direction of discharge on the ascent of fresh water in salt water	4595
	216—"Influence of sewage pollution"	4603
Defendants' Exhibit	4—Map	4619
Defendants' Exhibits	6 and 7—Certified copy of approval of War Department to Passaic Valley sewage project—stipulation between United States and Passaic Valley Sewerage Commissioners, April 14, 1910	4619

VOLUME V.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,

vs.

STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

EXHIBITS

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 99.

JAMES D. MAHER,
Commissioner.

SUBJECT: DISPOSAL METHODS - Dilution — PLATE NO. 205
NEW YORK HARBOR Dissolved Oxygen in PPM - Cross-Sections — ADD. NO. 1H417
Averages for 10 Locations - 1062 Samples Taken on 20 Days. — SHEET NO. OF NO. OF SHEETS
COMPUTED BY: BAH. CHECKED BY: DATE: Jan. 17. 1912

LOCATION	DISSOLVED OXYGEN						No. of Samples	Date 1911	Reference
	BOTH CURRENTS		EBB CURRENT		FLOOD CURRENT				
	CC per Liter	% of Saturation	CC per Liter	% of Saturation	CC per Liter	% of Saturation			
HUDSON R. at Mt St Vincent	4.11	69	4.19	70	4.04	67	30	June 29	305 W.540+578
	3.98	76	3.82	80	4.00	73	90	Oct 13	" " 923 W.610
	4.60	73	4.77	75	4.42	70	120		
HUDSON R. at the Mouth	—	—	3.14	56	—	—	15	July 19	" " 384 W.383
	3.11	56	3.02	54	3.20	58	45	July 20	" " 846 W.384
	2.98	55	2.86	52	3.14	58	45	Aug 10	" " 353 W.891
	3.19	54	3.06	53	3.31	58	105	Sept 28	" " 359 W.357
	3.09	56	3.01	54	3.22	58	210		
EAST RIVER at Throgs Neck	5.25	86	5.41	89	5.05	83	54	Oct 25	" " 978 W.416
EAST RIVER at Clason Point	3.72	67	4.24	77	3.20	56	20	June 30	" " 341 W.389
EAST RIVER at Lawrence Pt	—	—	—	—	3.05	54	45	July 18	" " 345 W.397
	3.43	57	3.28	60	3.38	54	64	Oct 11	" " 348 W.404
	3.43	57	3.68	69	3.14	55	99		
EAST RIVER, AT THE MOUTH	3.01	55	2.90	53	3.12	57	45	July 27	" " 349 W.506
	3.04	56	2.98	54	3.14	57	45	Aug 3	" " 300 W.933
	3.08	54	2.95	52	3.21	57	90	Sept 29	" " 367 W.509
	3.04	55	2.98	53	3.16	57	180		
KILL VAN KULL, EAST END	4.43	75	4.41	74	4.45	76	54	Oct 4	" " 348 W.401
THE NARROWS at Forts	—	—	3.86	73	—	—	21	Aug 9	" " 901 W.890
	4.42	79	4.28	76	4.51	82	105	Sept 26	" " 3264 W.394
	4.42	79	4.07	74	4.57	82	183		
UPPER BAY, in vicinity of Robbins Reef	4.29	71	4.03	66	4.55	76	45	Oct 16	" " 3748 W.412
	4.43	73	4.44	70	4.79	77	36	Oct 23	" " 378 W.413
	4.89	76	5.14	80	4.64	73	36	Oct 24	" " 8764 W.414
	4.60	73	4.54	72	4.66	75	117		
NEWARK BAY, Lower End	4.02	64	4.22	67	3.82	61	66	Oct 6	" " 966 W.404

Compliment: Enclosed No 99 - P. [illegible] James D. Mahon Commissioner

Subject: DISPOSAL METHODS - Dilution File No. 205
New York Harbor Dissolved Oxygen in 1911 Hudson River Acc. No. 1H340
Average % of Saturation from Cross-Sections At Mt St Vincent Sheet
Computed by: CCLM Checked by Date June 3 1912

Date of collection June 29 1911 HW Gov I. 10[23] AM I W Gov I. 4[27] PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current all Depths	both Currents all Depths
Flood Current						
Depth 1 ft.	29	9.41 AM	67 %	%	%	%
	26	10.10 "	67			
	29	10.40 "	67			
	32	11.20 "	72			
	35	11.55 "	72	69.0 (5 samples)		
Mid-depth	24	9.42 "	62			
	27	10.12 "	63			
	30	10.42 "	68			
	33	11.22 "	68			
	36	11.57	72	66.6 (5 samples)		
Bottom	25	9.45 "	62			
	28	10.15 "	63			
	31	10.45 "	68			
	34	11.25 "	68			
	37	12.00 PM	72	(5 samples) 66.6	(10 samples) 67.4	
Ebb Current						
Depth 1 Ft.	38	3.20 PM	68			
	41	3.52 "	68			
	44	4.10 "	72			
	47	4.30 "	78			
	50	4.50 "	78	(5 samples) 72.4		
Mid-depth	39	3.28 "	68			
	42	3.53 "	68			
	45	4.12 "	78			
	48	4.32 "	72			
	51	4.52 "	72	(5 samples) 70.6		
Bottom	40	3.25 "	63			
	43	3.55 "	63			
	46	4.15 "	69			
	49	4.35 "	68			
	52	4.56 "	73	(6 samples) 67.2	(12 samples) 70.2	(30 samples) 69 %

Ex. 99-P. 2

Subject: Disposal Methods Dilution — File No 20.5
New York Harbor Dissolved Oxygen in 1911 Hudson River — Acc No 1M 379
Average C.C. per Liter - from Cross Sections. At Mt. St. Vincent — Toy in Court
Computed by GAM. Checked by — Date June 10 1912

Date of Collection June 29, 1911 HW Gov. I 10[53] AM LW 4[43] PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depths
Flood Current						
Depth 1 Ft.	23	9.40 AM	4.00			
	26	10.10 "	4.05			
	29	10.40 "	4.05			
	32	11.20	4.35	(3 samples)		
	35	11.65 "	4.33	4.16		
Mid-depth	24	9.42 "	3.74			
	27	10.12 "	3.74			
	30	10.42 "	4.05			
	33	11.22 "	4.05	(3 samples)		
	36	11.57 "	4.33	3.98		
Bottom	25	9.45 "	3.74			
	28	10.15	3.74			
	31	10.45 "	4.05			
	34	11.25 "	4.05	(5 samples)	(11 samples)	
	37	12.00 M	4.33	3.98	4.04	
Ebb Current						
Depth 1 Ft.	38	3.20 PM	4.05			
	41	3.52 "	4.05			
	44	4.10 "	4.34			
	47	4.30 "	4.68	(5 samples)		
	50	4.50 "	4.68	4.38		
Mid-depth	39	3.33 "	4.05			
	42	3.53 "	4.05			
	45	4.12 "	4.35			
	48	4.32 "	4.35	(5 samples)		
	51	4.52 "	4.33	4.22		
Bottom	40	3.25 "	3.74			
	43	3.55 "	3.74			
	46	4.15 "	4.05			
	49	4.36 "	4.05	(5 samples)	(11 samples)	(16 samples)
	52	4.58 "	4.33	3.98	4.19	4.11

Cr 99-11 3

Subject: Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911 HUDSON RIVER
Average % of Saturation from Cross Section At Mt. St. Vincent
Computed by: B.A.W. Checked by:
Plan No. 20-5
Acc. No. 111369
Sheet 1 Tot. in Group 4
Date Jan. 9 1912

Date of Collection Oct. 13 1911. L.W. Gov. I. 6.2 AM H.W. 11.8 AM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation. Each Current. Each Depth	All Depths	Both Currents. All Depths
Ebb Current Depth 1 Ft	1948	7.45 AM	84%			
	1951	7.53 "	85			
	1954	8.01 "	96			
	1957	8.09 "	88			
	1960	8.17 "	97			
	1963	9.48 "	86			
	1966	9.58 "	86			
	1969	10.01 "	87			
	1972	10.09 "	88			
	1975	10.17 "	87			
	2008	4.00 PM	73			
	2011	4.08 "	74			
	2014	4.16 "	77			
	2017	4.24 "	78			
	2020	4.32 "	79			
	2023	5.18 "	77			
	2026	5.23 "	78			
	2029	5.30 "	78			
	2032	5.38 "	79	(Incomplete)		
	2035	5.46 "	81	91.2 %		

In 99-00

Survey: Disposal Methods - Dibblon — File No. 20.5
Harbor: Dissolved Oxygen in 1911 Hudson River — Acc. No. 11370
Average % of Saturation from Cross Section at Mt. St. Vincent — Sheet 2 Tot. in Case 4
Computed by: Cobb — Checked by: — Date: Jan 9 — 12

Date of Collection Oct. 13. 1911 11 Gen 1 v. Pam 11 v 6 MAM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current: Each Depth	All Depths	Both Currents on All Depths
Ebb Current Mid-depth	1949	7.43 AM	78 %			
	1952	7.55 "	79			
	1955	8.05 "	83			
	1958	8.11 "	83			
	1961	8.19 "	83			
	1964	9.47 "	74			
	1967	9.55 "	79			
	1970	10.03 "	84			
	1973	10.11 "	85			
	1976	10.19 "	84			
	2009	4.02 PM	74			
	2012	4.10 "	75			
	2015	4.18 "	78			
	2018	4.26 "	77			
	2021	4.34 "	78			
	2024	5.17 "	78			
	2027	5.25 "	79			
	2030	5.32 "	79			
	2033	5.40 "	81	Incomplete		
	2036	6.48 "	72	79.8 %		

6a. 97-P 5

Subject: Dissolved Oxygen in the Hudson River File No. 20.5
Title: Dissolved Oxygen in the Hudson River Exhibit No. 1937
Survey % of Saturation. Flow Cross Sections. At Mt St Vincent Sheet 3 of 4
Computed by: R.A.V. Checked by: Date: Jan 9. 19 38

Date of Collection: Oct 13, 1931 LW Gov I 5:12 AM HW 11:49 AM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Both Currents Each Depth	Both Currents All Depths	Both Current All Depths
Ebb Current						
Depth 1 ft. see sheet 1				Surface 81.8 %		
Mid. depth see sheet 2.				Bottom 79.8		
Bottom	1950	7:49 AM	78			
	1952	7:57 "	80			
	1954	8:05 "	83			
	1959	8:13 "	88			
	1962	8:21 "	93			
	1965	9:45 "	71			
	1968	9:37 "	79			
	1971	10:05 "	84			
	1974	10:13 "	85			
	1977	10:21 "	84			
	2010	4:04 PM	76			
	2013	4:12 "	75			
	2016	4:20 "	78			
	2019	4:28 "	77			
	2022	4:36 "	78			
	2025	5:19 "	75			
	2028	5:27 "	79			
	2031	5:34 "	79			
	2034	5:42 "	81	Surface	Surface	
	2037	5:50 "	82	80.0	80.5 %	
Flood Current. see sheet 4						

Co 99-P 6

DARK PAGE BL

Case: Disposal Methods Division — File No. 20.5
New York Harbor Dissolved Oxygen in 1981 Hudson River Acc. No. IM372
Average % of Saturation - from Cross Sections at Mt of Vineyard Sheet 4 Tot. in Sheet 4
Computed by: BCM Checked by: Date: Jan. 9 19 82

Date of Collection Oct 13 1981 LW 6m I 5th AM HW 11th AM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depth
Ebb Current					80.5%	
Flood Current						
Depth 1 ft.	1979	11:45 AM	74			
	1981	11:50 "	78			
	1994	12:01 PM	78			
	1997	12:09 "	76			
	1990	12:13 "	77			
	1993	2:00 "	74			
	1996	2:08 "	73			
	1999	2:10 "	74			
	2002	2:24 "	75			
	2005	2:32 "	69	(2 samples) 74.7%		
Mid-depth	1978	11:48 AM	73			
	1982	11:58 "	73			
	1995	12:05 PM	74			
	1988	12:11 "	75			
	1991	12:19 "	76			
	1994	2:02 "	67			
	1997	2:16 "	68			
	2000	2:18 "	68			
	2003	2:26 "	69	(2 samples)		
	2006	2:34 "	70	71.2		
Bottom	1980	11:49 AM	72			
			Same as Mid depth	(2 samples)	(3 samples)	(5 samples)
	2007	2:36 PM	70	71.2	72.4	76.7%

to 11 AM

SUBJECT DISPOSAL METHODS. Dilution — FILE NO 20.5
NEW YORK HARBOR Dissolved Oxygen in 1911 HUDSON RIVER — ACC NO 11407
Average C.C. per Liter from Cross Sections AT MT. ST. VINCENT — SHEET 1 TOT IN COMP 1
COMPUTED BY ELLY. CHECKED BY — DATE Jan 15 1912.
MADE IN CONNECTION WITH

Date of Collection Oct. 13. 1911 LW Gov I 5[19] AM HW 11[32] AM.

	Sample No.	Time	Oxygen C.C per Liter	Averages. C.C. per Liter. Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Ebb Current Depth 1 FT.	1948	7.45 AM	5.74			
	1951	7.53 "	5.83			
	1954	8.01 "	5.85			
	1957	8.03 "	5.87			
	1960	8.17 "	5.94			
	1963	9.45 "	5.74			
	1966	9.59 "	5.83			
	1969	10.01 "	5.88			
	1972	10.09 "	5.97			
	1976	10.17	6.94			
	2003	4.00 PM	4.78			
	2011	4.08 "	4.87			
	2014	4.16 "	5.04			
	2017	4.24 "	5.11			
	2020	4.32 "	5.22			
	2023	5.15 "	5.06			
	2026	5.23 "	5.14			
	2029	5.30 "	5.18			
	2032	5.38 "	5.26	(20 samples)		
	2035	5.46 "	5.36	5.49		

C. Ely. - 2

DARK PAGE BLE

Sub.... DISPOSAL METHODS Dilution — File No 20.5
New York Harbor Dissolved Oxygen in 1911 Hudson River — Acc. No 11408
Average C.C. per Liter from Cross Sections At Mt. St. Vincent — Sheet 2 Tot. in Comp 4
Computed by Catt — Checked by — Date Jan 15 1912
Made in connection with

Date of Collection Oct. 13, 1911 LW 6.17 I 5.9 AM HW 11.27 AM.

	Sample No.	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Ebb Current						
Mid depth	1949	7.47 AM	5.19			
	1952	7.55 "	5.28			
	1956	8.03 "	6.60			
	1958	8.11 "	5.63			
	1961	8.19 "	5.45			
	1964	8.41 "	5.19			
	1967	8.56 "	6.28			
	1970	10.03 "	6.60			
	1973	10.11	5.68			
	1976	10.19	5.65			
	2009	4.07 PM	4.78			
	2012	4.10 "	4.87			
	2015	4.18 "	5.04			
	2018	4.26 "	5.00			
	2021	4.34 "	5.07			
	2024	5.17 "	5.06			
	2027	5.25 "	5.14			
	2030	5.37 "	5.18			
	2033	5.40 "	5.36	(20 Samples)		
	2036	5.48 "	5.36	5.28		

Ex. 99-P 9

D THRU

Subject: DISPOSAL: METHODS: Dilution File No 20.5
NEW YORK HARBOR Dissolved Oxygen in 1911 HUDSON RIVER Page No 1H409
Average C.C. per Liter - From Cross-Sections AT MT. ST VINCENT Sheet 3 Tot. in Case 4
Computed by GAH. Checked by Date Jan 15 1912.
Made in connection with

Date of Collection Oct. 13. 1911 L.W. Gov. I. 8.42 AM H.W. 11.52 AM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current, Each Depth	Each Current, All Depth	Both Currents - All Depths
Ebb Current						
Depth 1 Ft. see sheet 1				(10 samples) 5.49		
Mid-depth see sheet 2				(40 samples) 5.28		
Bottom	1950	7.49 AM	5.19			
	1953	7.57 "	5.28			
	1956	8.05 "	5.60			
	1959	8.13 "	5.68			
	1962	8.21 "	5.65			
	1965	9.49 "	5.19			
	1968	9.57 "	5.23			
	1971	10.05 "	5.60			
	1974	10.13 "	5.68			
	1977	10.21 "	5.65			
	2010	4.04 PM	4.94			
	2013	4.12 "	4.87			
	2016	4.20 "	5.04			
	2019	4.28 "	5.00			
	2022	4.36 "	5.07			
	2025	5.13 "	5.06			
	2028	5.27 "	5.14			
	2031	5.34 "	5.18			
	2034	5.42 "	5.26	(20 samples)	(60 samples)	
	2037	5.50 "	5.36	5.29	5.35	

Ex 99 P. 10

DARK PAGE BLEE

SUBJECT DISPOSAL METHODS - Dilution FILE NO 20.5
NEW YORK HARBOR - Dissolved Oxygen in 1911 HUDSON RIVER ACC. NO 1H410
Average C.C per Liter from Cross-Sections AT MT ST. VINCENT SHEET 4 TOT. IN COMP. 4
COMPUTED BY Galt. CHECKED BY DATE Jan 15 1912.
NAME OF CONNECTION WITH

Date of Collection Oct. 13. 1911 LW Gov. I. 5^15 AM HW 11^37 AM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter. Each Current: Each Depth	Each Current: All Depths	Both Currents - All Depths
Ebb Current. see sheet 3					(60 samples) 5.35	
Flood Current						
Depth 1 Ft	1978	11.45AM	4.94			
	1981	11.53 "	5.00			
	1984	12.01PM	5.04			
	1987	12.09 "	5.11			
	1990	12.17 "	5.22			
	1958	2.00 "	4.78			
	1996	2.08 "	4.87			
	1999	2.16 "	4.90			
	2002	2.24 "	5.00	(10 samples)		
	2005	2.32 "	5.07	4.99		
Mid-depth	1979	11.47AM	4.78			
	1982	11.55 "	4.87			
	1985	12.03PM	4.90			
	1988	12.11 "	5.00			
	1991	12.19 "	5.07			
	1994	2.02 "	4.38			
	1997	2.10 "	4.44			
	2000	2.18 "	4.48			
	2003	2.26 "	4.55	(10 samples)		
	2006	2.34 "	4.64	4.71		
Bottom	1980	11.49AM	4.78			
	⋮	⋮	Same as Mid depth	(10 samples)	(30 samples)	(30 samples)
	2007	2.36PM	4.64	4.71	4.80	5.08

Ex 99-P 11

THRU

Subject: Disposal Methods Dilution
New York Harbor - Dissolved Oxygen in 1911 — Mouth of Hudson River
Average % of Saturation - from Cross Section
Computed by: GAH Checked by: Date: Jan 3 1912
File No. 20.5 Acc. No. 1H344 Sheet Toy in Comp

Date of Collection July 19, 1911 LW Gov. I. 7.27 AM HW Gov. I 1.52 PM.

	Sample No.	Time	% of Saturation	Averages Percent of Saturation: Each Current — Each Depth	Each Current — All Depths	Both Currents All Depths
Ebb Current						
Depth 1 Ft	463	9.15 AM	53%			
	466	9.30 "	55			
	469	9.45 "	55			
	472	10.00 "	55	(5 samples)		
	475	10.15 "	58	55.6%		
Mid-depth	464	9.16 "	53			
	467	9.31 "	55			
	470	9.46 "	58			
	473	10.01 "	58	(5 samples)		
	476	10.16 "	58	56.4		
Bottom	465	9.18 "	53			
	468	9.33 "	55			
	471	9.48 "	58			
	474	10.03 "	58	(5 samples)	(15 samples)	
	477	10.18 "	58	56.4	56.1%	
Flood Current	no samples taken					

Cy 97-P 12

DARK PAGE BLE

SUBJECT: DISPOSAL METHODS- Dilution — FILE NO: 20.5
NEW YORK HARBOR Dissolved Oxygen in 1911 MOUTH OF — ACC NO: 1H383
Average C.C. per Liter. from Cross-Sections HUDSON RIVER — SHEET — TOT IN COMP
COMPUTED BY: EHH. — CHECKED BY — DATE: Jan. 11 1912

Date of Collection, July 19 1911 LW Gov. I. 7²⁷ AM 11.1 1²³ PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current- Each Depth	Each Current- All Depths	Both Currents. All Depths
Ebb Current						
Depth 1 Ft.	463	9.15 AM	3.09			
	466	9.30 "	3.09			
	469	9.45 "	3.24			
	472	10.00 "	3.09	(5 samples)		
	475	10.15 "	3.00	3.12		
Mid-depth	464	9.16 "	2.95			
	467	9.31 "	3.09			
	470	9.46 "	3.24			
	473	10.01 "	3.24	(5 samples)		
	476	10.16 "	3.24	3.15		
Bottom	465	9.18 "	2.95			
	468	9.33 "	3.09			
	471	9.48 "	3.24			
	474	10.03 "	3.24	(5 samples)	(15 samples)	
	477	10.18 "	3.24	3.15	3.14	

Flood Current. no samples taken

Ex. 99 P. 13

SUBJECT DISPOSAL METHODS Dilution
New York Harbor Dissolved Oxygen in 1911 MOUTH OF
Average % of Saturation - from Cross Sections HUDSON RIVER
COMPUTED BY ELH. CHECKED BY
FILE NO 20.5
ACC NO 1H345
SHEET 1 TOT. IN COMP 2
DATE Jan 3, 1913.

Date of Collection July 20 1911 LW Gov. I. 8.27 AM HW Gov. I 2.53 PM.

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current		Both Currents All depths
Ebb Current						
Depth 1 Ft.	478	9.15 AM	53%			
	481	9.23 -	54			
	484	9.33 -	54			
	487	9.40 -	56	(5 samples)		
	490	9.46 -	55	54.4%		
Mid-depth	479	9.16 -	53			
	482	9.24 -	54			
	485	9.34 -	54			
	488	9.41 -	56	(5 samples)		
	491	9.47 -	55	54.4		
Bottom	480	9.18 -	53			
	483	9.26 -	54			
	486	9.36 -	54			
	489	9.43 -	56	(5 samples)	(5 samples)	
	492	9.49 -	55	54.4	54.4%	
Flood Current, see sheet 2.						

Ex. 99-P. 19

DARK PAGE BL

Subject: Disposal Methods - Dilution — File No. 205
New York Harbor Dissolved Oxygen in 1911 Mouth of — Acc. No. IH346
Average % of Saturation - from Cross Sections Hudson River — Sheet 2 of 2 Sheets
Computed by: Leah — Checked by: — Date: Jan. 3, 1912

Date of Collection: July 20 1911 LW Gov I 8³⁷ AM HW Gov I 2⁵² PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depths
Ebb Current. See sheet 1					54.4% (18 samples)	
Flood current						
Depth 1 Ft.	493	12.15 PM	56%			
	496	12.23 -	57			
	499	12.31 -	57			
	502	12.39 -	59			
	505	12.47	57			
	508	2.15 -	59			
	511	2.22 -	59			
	514	2.30 -	59			
	517	2.38 -	59	(18 samples)		
	520	2.46 -	57	57.9%		
Mid-depth	494	12.16 -	56			
	497	12.24 -	57			
	500	12.32 -	57			
	503	12.40 -	58			
	506	12.48 -	57			
	509	2.16 -	59			
	512	2.23 -	60			
	515	2.31 -	60			
	518	2.39 -	59	(18 samples)		
	521	2.47 -	58	58.1		
Bottom.	495	12.18 -	56			
	498	12.26 -	57			
	501	12.34 -	57			
	504	12.42 -	58			
	507	12.50 -	57			
	510	2.18 -	59			
	513	2.25 -	60			
	516	2.33 -	60			
	519	2.41 -	59	(18 samples)	(36 samples)	(54 samples)
	522	2.49 -	58	58.1	58.0	56%

Ex. 99 - P. 15

ED THRU

SUBJECT DISPOSAL METHOD Dilution — FILE NO 20.5
NEW YORK HARBOR Dissolved Oxygen in 1911 MOUTH OF HUDSON RIVER — ACC NO 11384
Average CC per Liter from Cross-Sections — SHEET — TOT. IN CASE
COMPUTED BY CCH — CHECKED BY — DATE Jan. 11 1912
MADE IN CONNECTION WITH

Dates of collection July 20 1911 LW Gov I 8.27 AM HW 2.58 PM

	Sample No.	Time	Oxygen CC per Liter	Averages CC per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Ebb Current						
Depth 1 Ft	473	9.10 AM	2.95			
	481	9.23	3.00			
	484	9.33	3.01			
	487	9.40	3.10	(4 samples)		
	490	9.46	3.03	3.02		
Mid depth	475	9.16	2.91			
			Same as Depth 1 Ft	(4 samples)		
	491	9.47	3.03	3.02		
Bottom	480	9.18	2.95			
			Same as Depth 1 Ft	(4 samples)	(8 samples)	
	492	9.48	3.03	3.02	3.02	
Flood Current						
Depth 1 Ft	493	12.15 PM	3.09			
	496	12.23	3.14			
	499	12.31	3.15			
	502	12.39	3.14			
	505	12.47	3.17			
	508	2.15	3.24			
	511	2.23	3.29			
	514	2.30	3.29			
	517	2.38	3.32	(8 samples)		
	520	2.46	3.17	3.20		
Mid depth	494	12.16	3.09			
			Same as Depth 1 Ft	(2 samples)		
	521	2.41	3.17	3.20		
Bottom	495	12.18	3.09			
			Same as Depth 1 Ft	(2 samples)	(4 samples)	(16 samples)
	522	2.49	3.17	3.20	3.20	3.11

E. 99 P 16

DARK PAGE

Subject: Disposal Methods Dilution — File No 205
New York Harbor. Dissolved Oxygen in 1911 Mouth of — Acc No 1M552
Average % of Saturation from Cross Sections Hudson River Sheet 1 Tot in Comp 2
Computed by BCH. Checked by — Date Jan 4 1912
Map in connection with

Date of Collection Aug 10 1911 HWGT. 8.29 AM LW 2.21 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: each Current — Each Depth	each Current — All Depth	Both Currents All Depths
Flood Current						
Depth 11 Ft.	903	9.10 AM	54%			
	905	9.17 -	56			
	909	9.24 -	57			
	917	9.30 -	58	(5 samples)		
	915	9.37 -	56	56.0%		
Mid depth	904	9.11 -	57			
	907	9.18 -	58			
	910	9.25 -	59			
	913	9.31 -	60	(5 samples)		
	916	9.38 -	58	58.4		
Bottom	906	9.13 -	57			
	908	9.20 -	58			
	911	9.27 -	59			
	914	9.33 -	60	(5 samples)	(15 samples)	
	917	9.40 -	58	58.4	57.6%	
Ebb Current see sheet 2						

Ex. 99-P. 17

EED THRU

Subject: Disposal Methods - Dilution — File No. 20.9
Newtown Harbor Dissolved Oxygen in 1911 Mouth of — Acc. No. 11355
Average % of Saturation from Cross Sections Hudson River — Sheet 2 of 2 Sheets
Computed by: Goff — Checked by: — Date: Jan. 4 — 1912

Date of Collection Aug 10 1911. HWG1 8[10] AM LW Gov'I 2[37] PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation: Each Current, Each Depth	Each Current, All Depths	Both Currents & All Depths
Flood Current (at start)					57.6% (2 samples)	
Ebb Current						
Depth 1 ft	918	11:08 AM	49%			
	921	11:17 "	53			
	924	11:24 "	54			
	927	11:30 "	53			
	930	11:37 "	50			
	933	1:30 PM	49			
	936	1:37 "	50			
	939	1:44 "	51			
	942	1:50 "	50	(2 samples)		
	945	1:57 "	47	50.5 %		
Mid depth	919	11:11 AM	51			
	922	11:18 "	53			
	925	11:28 "	54			
	928	11:31 "	55			
	931	11:38 "	52			
	934	1:31 PM	51			
	937	1:38 "	53			
	940	1:45 "	54			
	943	1:51 "	53	(2 samples)		
	946	1:58 "	50	52.5		
Bottom	920	11:13 AM	51			
	923	11:20 "	53			
	926	11:27 "	54			
	929	11:33 "	55			
	932	11:40 "	53			
	935	1:33 PM	51			
	938	1:40 "	53			
	941	1:47 "	54			
	944	1:51 "	52	(10 samples)	(20 samples)	(30 samples)
	947	2:00 "	50	52.5	51.9	55 %

Cont'd

DARK PAGE

Subject: Disposal Methods Dilution — File No. 205
New York Harbor Dissolved Oxygen in ppl Mouth of — Acc. No. IN 390
Average CC per Liter from Cross Sections Hudson River — Sheet 1 for 2 Sheets 2
Computed by GLM — Checked by — Date Jan. 11 19 15

Date of Collection Aug. 10, 1911 Flow Gov. I. 8^M AM Lw 2.37 PM

	Sample No.	Time	Oxygen CC per Liter	Averages CC per Liter: Each Current — Each Depth	Each Current — All Depths	Both Currents in All Depths
Flood Current						
Depth 1 Ft	903	9:16 AM	3.37			
	906	9:17 "	3.05			
	909	9:24 "	3.09			
	912	9:30 "	3.16	(Incomplete)		
	915	9:37 "	3.01	3.05		
Mid-depth	904	9:11 AM	3.10			
	907	9:18 "	3.13			
	910	9:25 "	3.24			
	913	9:31 "	3.40	(Incomplete)		
	916	9:38 "	3.15	3.19		
Bottom	905	9:13 "	3.12			
	908	9:20 "	3.17			
	911	9:27 "	3.24			
	914	9:33 "	3.23	(Incomplete)	(Incomplete)	
	917	9:40 "	3.15	3.18	3.14	
Ebb Current	see sheet 2					

L. or GB

EED THRU

Dissolved Oxygen Determinations Dilution — Form No. 205
New York Harbor Dissolved Oxygen in PPM — MOUTH OF HUDSON RIVER — Order No. 111591
Average CC per Liter - From Curve Sections — Order 2 to Cover 2.
Computed by: E.A.H. — Checked by: — Date: Jan. 11 1915

Date of Collection Aug 10 1911 Raw Gov I 8 AM 1.W 2 PM

	Sample No	Time	Oxygen CC per Liter	Averages CC per Liter		
				East Current		Both Currents
				Each Depth	All Depths	All Depths
Flood Current (see sheet)					(2 samples) 3.14	
Ebb Current						
Depth 15 Ft.	918	11:10 AM	2.76			
	921	11:17 "	2.80			
	924	11:24 "	2.97			
	927	11:30 "	2.86			
	930	11:37 "	2.76			
	933	1:30 PM	2.74			
	936	1:37 "	2.76			
	939	1:44 "	2.80			
	942	1:50 "	2.72	(average)		
	945	1:57 "	2.60	2.77		
Mid-depth	919	11:11 AM	2.81			
	922	11:18 "	2.90			
	925	11:25 "	2.88			
	928	11:31 "	3.00			
	931	11:38 "	2.98			
	934	1:31 PM	2.81			
	937	1:38 "	2.90			
	940	1:45 "	2.95			
	943	1:51 "	2.86	(average)		
	946	1:58 "	2.76	2.88		
Bottom	920	11:13 AM	2.81			
			Same as Mid depth	(average)	(average)	(All samples)
	947	2:00 PM	2.76	2.88	2.84	2.22

Ebb = 20

DARK PAGE BL

Subject: Disposal Methods Dilution — File No. 205
Area: New York Harbor Dissolved Oxygen in PPM — Area No. IM357
Average % of Saturation from Cross Sections — MOUTH OF HUDSON RIVER — Sheet 1 Top 2 Cond. 3
Computed by: Cal N — Checked by: — Date: Jan 5 19 17

Date of Collection Sept 28, 1916 LW Gov I 6.7 AM HW 12.18 PM LW 6.27 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation: Each Current, Each Depth	Each Current, All Depths	Both Currents All Depths
Ebb Current						
Depth 1 Ft	1579	6.30 AM	52%			
	1582	6.33 "	53			
	1585	6.48 "	50			
	1588	6.93 "	54			
	1591	7.06 "	53			
	1594	7.30 "	47			
	1597	7.39 "	50			
	1600	7.48 "	52			
	1603	8.57 "	91			
	1606	9.04 "	86			
	1634	4.30 PM	53			
	1637	4.39 "	54			
	1640	4.48 "	56			
	1643	4.57 "	55			
	1646	5.06 "	51			
	1649	6.00 "	47			
	1672	6.06 "	48			
	1675	6.13 "	55			
	1678	6.20 "	53	Interpolated		
	1681	6.27 "	51	51.8%		

SUBJECT: DISPOSAL METHODS Dilution FILE NO 205
NEW YORK HARBOR Dissolved Oxygen in 1911 MOUTH OF ACC. NO 1H358
Average % of Saturation from Cross Sections. HUDSON RIVER SHEET 2 TOT. IN COMP 3
COMPUTED BY [illegible] CHECKED BY DATE Jan. 5 1912
MADE IN CONNECTION WITH

Date of Collection Sept 28, 1911 LW Gov I 6^m AM HW 12^h 10^m PM LW 6^h 2^m PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation		
				Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Ebb Current				(30 samples)		
Depth 1 Ft see sheet 1				51.8%		
Mid-depth	1580	6 32 AM	52 %			
	1583	6 41 "	54			
	1586	6 5" "	55			
	1589	6 59 "	54			
	1592	7 08 "	55			
	1595	8 32 "	51			
	1598	8 41 "	51			
	1601	8 50 "	52			
	1604	8 59 "	54			
	1607	9 08 "	53			
	1655	4 32 PM	56			
	1658	4 41 "	57			
	1661	4 50 "	58			
	166	4 59 "	59			
	1667	5 08 "	56			
	1670	6 01 "	51			
	1673	6 07 "	52			
	1676	6 14 "	52			
	1679	6 21 "	53	(30 samples)		
	1682	6 28 "	53	53.9		
Bottom	1581	6 34 AM	52			
			Same as Mid-depth			
	1683	6 30 PM	53	53.9	(60 samples) 53.2%	

Eq 99 P 22

SUBJECT DISPOSAL METHODS - Dilution
NEW YORK HARBOR - Dissolved Oxygen in 1911 MOUTH OF HUDSON RIVER
Average % of Saturation - from Cross-Sections
COMPUTED BY East CHECKED BY
FILE NO 205
ACC. NO. 1H359
SHEET 3 TOT. IN COMP. 3
DATE Jan. 5 1912
MADE IN CONNECTION WITH

Date of Collection Sept 28, 1911 LW Gov I 6.27 AM HW 12.13 PM LW 6.27 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation	
				Each Current	Both Currents
				Each Depth	All Depths	All Depths
Ebb Current see sheet 2					53.2% (66 samples)	
Flood Current						
Depth 1 Ft.	1609	10.30 AM	50 %			
	1612	10.39 "	53			
	1615	10.48 "	55			
	1618	10.57 "	56			
	1621	11.06 "	53			
	1624	12.30 PM	55			
	1627	12.39 "	55			
	1630	12.48 "	57			
	1633	12.57 "	57			
	1636	1.06 "	55			
	1639	2.30 "	58			
	1642	2.39 "	59			
	1645	2.48 "	60			
	1648	2.57 "	61	(15 samples)		
	1651	3.06 "	60	56.3%		
Mid-depth	1610	10.33 AM	53			
	1613	10.41 "	54			
	1616	10.50 "	55			
	1619	10.59 "	57			
	1622	11.08 "	55			
	1625	12.32 PM	57			
	1628	12.41 "	59			
	1631	12.50 "	60			
	1634	12.59 "	61			
	1637	1.08 "	58			
	1640	2.32 "	60			
	1643	2.41 "	62			
	1646	2.50 "	63			
	1649	2.59 "	64	(15 samples)		
	1652	3.08 "	61	58.6		
Bottom	1611	10.34 AM	53			
			same as Mid-Depth	(15 samples)	(15 samples)	(30 samples)
	1653	3.10 PM	61	58.6	57.8	56 %
					Ex 99	p 23

SUBJECT: DISPOSAL METHOD - Dilution
NEW YORK HARBOR - Dissolved Oxygen in 1911 MOUTH OF
Average C C per Liter - From Cross Sections HUDSON RIVER
COMPUTED BY: C.A.M. CHECKED BY:
DATE IN CONNECTION WITH:

FILE NO 205
ACC NO 111395
SHEET 1 TOT IN COMP 3
DATE Jan. 12 1912

Date of Collection Sept. 28. 1911 LW Gov I 6h07 AM 11W12h12 PM LW6h07 PM

	Sample No	Time	Oxygen C C per Liter	Averages. C C per Liter		
				Each Current		Both
				Each Depth	All Depths	Currents & All Depths
Ebb Current Depth 1 Ft	1579	6 36 AM	3.01			
	1582	6 39 "	3.09			
	1585	6 48 "	3.19			
	1588	6 57 "	3.12			
	1591	7 06 "	3.06			
	1594	8 30 "	2.73			
	1597	8 39 "	2.84			
	1600	8 48 "	3.04			
	1603	8 57 "	3.00			
	1606	9 06 "	2.32			
	1654	4 30 PM	3.01			
	1657	4 39 "	3.09			
	1660	4 48 "	3.12			
	1663	4 57 "	3.19			
	1666	5 06 "	3.06			
	1669	6 00 "	2.73			
	1672	6 06 "	2.80			
	1675	6 13 "	3.00			
	1678	6 20 "	3.04	(resampled)		
	1681	6 27 "	2.82	3.00		
					3.99	p 24

SUBJECT: DISPOSAL METHODS Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911 MOUTH OF
Average C C per Liter. from Cross Sections HUDSON RIVER
COMPUTED BY: Ed H CHECKED BY:
FILE NO 205
ACC NO 1H396
SHEET 2 TOT IN CONN 3
DATE Jan 12 1912
AND IN CONNECTION WITH:

Date of Collection Sept 28 1911 LW Gov I 6.7 AM HW 12.3 PM LW 6.7 PM

	Sample No.	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Ebb Current						
Depth 1 Ft seathest 1				(2 samples) 3.00		
Mid-depth	1580	6 32 AM	3.01			
	1583	6 41 "	3.08			
	1586	6 50 "	3.19			
	1589	6 59 "	3.12			
	1592	7 08 "	3.19			
	1595	8 32 "	2.92			
	1598	8 41 "	2.94			
	1601	8 50 "	3.04			
	1604	8 59 "	3.12			
	1607	9 08 "	3.06			
	1655	4.32 PM	3.14			
	1658	4.41 "	3.22			
	1661	4.50 "	3.27			
	1664	4.59 "	3.33			
	1667	5.08 "	3.19			
	1670	6.01 "	2.92			
	1673	6.07 "	2.94			
	1676	6.14 "	3.00			
	1679	6.21 "	3.04	(30 samples)		
	1682	6.28 "	3.06	3.09		
Bottom	1581	6.34 AM	3.01			
			Same as Mid depth	(30 samples)	(60 samples)	
	1683	6.30 PM	3.06	3.09	3.06	
					Ex 99	P 25

SUBJECT: DISPOSAL METHODS - Dilution — PLAT NO 20.5
New York Harbor Dissolved Oxygen in 1911 — MOUTH OF — ACC NO 11397
Average C.C. per Liter. From Cross-Sections — HUDSON RIVER — SHEET 3 TOT IN CONF 3
COMPUTED BY: CCM. — CHECKED BY — DATE Jun 12 1912.
MADE IN CONNECTION WITH

Date of Collection Sept 28 1911 LW Gov I 6h7 AM HW 12h9 PM LW 6h7 PM

	Sample No	Time	Oxygen C C per Liter	Average C C per Liter: Each Current, Each Depth	Average C C per Liter: Each Current, All Depths	Average C C per Liter: Both Currents - All Depths
Ebb Current see sheet 2					3.06 (20 samples)	
Flood Current						
Depth 1 Ft	1609	10 30 AM	2 87			
	1612	10 30 "	3 01			
	1615	10 48 "	3 19			
	1618	10 57 "	3 27			
	1621	11 06 "	3 06			
	1624	12 36 PM	3 16			
	1627	12 59 "	3 19			
	1630	12 48 "	3 37			
	1633	12 37 "	3 33			
	1636	1 06 "	3 19			
	1639	2 30 "	3 38			
	1642	2 39 "	3 36			
	1645	2 48 "	3 41			
	1648	2 57 "	3 48	(10 samples)		
	1651	3 06 "	3 47	3 24		
Mid-depth	1610	10 39 AM	3 01			
	1613	10 41 "	3 08			
	1616	10 50 "	3 19			
	1619	10 59 "	3 27			
	1622	11 08 "	3 19			
	1625	12 52 PM	3 26			
	1628	12 41 "	3 34			
	1631	12 50 "	3 41			
	1634	13 59 "	3 48			
	1637	1 08 "	3 33			
	1640	2 32 "	3 41			
	1643	2 41 "	3 50			
	1646	2 50 "	3 35			
	1649	2 59 "	3 62	(9 samples)		
	1652	3 08 "	3 47	3 34		
Bottom	1611	10 44 AM	3 01			
			Same as Mid-depth	(9 samples)	(20 samples)	(40 samples)
	1653	3 10 PM	3 47	3 34	3 31	3 18

Ev 99 P 26

SUBJECT Disposal Methods - Dilution
New York Harbor Dissolved Oxygen in 1911 EAST RIVER
Average % of Saturation - from Cross Sections AT THROGGS NECK
COMPUTED BY Gaff - CHECKED BY
FILE NO 20.5
ACC. NO 1H378
SHEET 2 TOT. IN COMP. 2
DATE Jan 10, 1912.

Date of Collection, Oct 25 1911 HW Gov't 9.22 AM.

	Sample No	Time	% of Saturation	Averages Percent of Saturation. Each Current Each Depth	Each Current All Depths	Both Currents - All Depths
Flood Current (W→E)	see sheet 1				(17 samples) 82.3%	
Ebb Current (W←E) Depth 1 Ft	2192	9.30 AM	81%			
	2195	9.42 "	73			
	2199	9.55 "	80			
	2181	11.30 "	88			
	2194	11.43 "	90			
	2197	11.55 "	91			
	2200	1.30 PM	88			
	2202	1.43 "	89	(9 samples)		
	2206	1.55 "	90	86.2%		
Mid depth	2193	9.32 AM	87			
	2196	9.44 "	88			
	2199	9.57 "	89			
	2192	11.32 "	89			
	2195	11.44 "	90			
	2198	11.57 "	91			
	2201	1.32 PM	91			
	2204	1.44 "	93	(9 samples)		
	2207	1.57 "	94	90.1		
Bottom	2194	9.35 AM	87			
			Same as Mid depth	(9 samples)	(17 samples)	(26 samples)
	2209	2.00 PM	94	90.1	88.8	86%

E. 99 ; P 17

Subject: DISPOSAL METHODS - Dilution — File No 205
New York Harbor Dissolved Oxygen in 1911 EAST RIVER AT THROGG'S NECK — Acc No 1H415
Average C.C. per Liter. from Cross-Sections — Sheet 1 for in Court 2.
Computed by CLH. Checked by — Date Jan 16. 1913.

Date of Collection Oct 25 1911 HW Gov I 9.22 AM.

	Sample No	Time	Oxygen C.C. per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents & All Depths
Flood Current (W→E) Depth 1 Ft.	2178	7.30 AM	4.38			
	2176	7.42 "	4.44			
	2179	7.55 "	4.48			
	2209	3.30 PM	5.19			
	2212	3.42 "	5.28			
	2215	3.55 "	5.32			
	2218	5.02 "	4.65			
	2221	5.12 "	4.72	(8 samples)		
	2224	5.25 "	4.76	4.80		
Mid-depth	2174	7.32 AM	4.94			
	2177	7.44	5.00			
	2180	7.57 "	5.04			
	2210	3.32 PM	5.10			
	2213	3.45 "	5.29			
	2216	3.57 "	5.32			
	2219	5.02 "	5.19			
	2222	5.14 "	5.28	(8 samples)		
	2225	5.27 "	5.32	5.17		
Bottom	2175	7.05 AM	4.94			
			same as Mid depth	(8 samples)	(31 samples)	
	2226	5.30 PM	5.32	5.17	5.05	
Ebb Current W←E)	see sheet 2.					

E. 49 M 48

Subject: Disposal Methods- Dilution Page No 205
New York Harbor Dissolved Oxygen in PPM EAST RIVER Acc No IM416
Average C.C. per Liter. From Cross-Sections AT TIMBOGS NECK Sheet 2 for in Case 2
Computed by CHM. Checked by Date Jan 16, 1912.

Date of Collection, Oct 25 1911 High Gau I 9.03 AM

	Sample No.	Time	Oxygen C C per Liter	Averages C C per Liter		
				Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current (W ⟶ E)	see sheet 1				(3 samples) 5.05	
Ebb Current (W ⟵ E)						
Depth 1 Ft.	2182	9.50 AM	4.94			
	2185	9.43 "	4.87			
	2188	9.55 "	4.90			
	2191	11.30 "	5.23			
	2194	11.43 "	5.42			
	2197	11.55 "	5.46			
	2200	1.30 PM	5.35			
	2203	1.13 "	5.41	(3 samples)		
	2206	1.55 "	5.46	5.24		
Mid depth	2183	9.33 AM	5.35			
	2186	9.46 "	5.43			
	2189	9.57 "	5.46			
	2192	11.32 "	5.33			
	2195	11.44 "	5.42			
	2198	11.57 "	5.46			
	2201	1.31 PM	5.60			
	2204	1.44 "	5.60	(3 samples)		
	2207	1.57 "	5.54	5.49		
Bottom	2184	9.35 AM	5.33			
			same as Mid-depth	(3 samples)	(6 samples)	(18 samples)
	2210	1.00 PM	5.74	5.43	5.41	5.23
					5.44	5.24

Subject: Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911 EAST RIVER
Average % of Saturation - from Cross Sections AT CLASON PT.
Computed by B.A.H. Checked by
File No 205
Acc. No 11341
Date Jan 3 1912

Date of Collection June 30, 1911 HW Gov I 1023 AM LW Gov I 537 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current — Mean Depth	Each Current — All Depths	Both Currents — All Depths
Flood Current (W→E)						
Depth 1 Ft	53	11 00 AM	60%			
	56	11 27 "	60			
	59	11 46 "	55			
	62	12 06 PM	55	(3 samples)		
	65	12 26 "	55	520%		
Mid-depth	54	11 03 AM	58			
	57	11 27 "	58			
	60	11 48 "	58			
	63	12 05 PM	55	(3 samples)		
	66	12 28 "	58	56.8		
Bottom	55	11 04 AM	55			
	58	11 30 "	55			
	61	11 50 "	56			
	64	12 10 PM	55	(3 samples)	(10 samples)	
	67	12 30 "	58	55.6	56.5%	
Ebb Current (W←E)						
Depth 1 Ft	77	2 20 PM	79			
	80	2 39 "	79			
	83	2 57 "	78			
	86	3 16 "	79	(3 samples)		
	89	3 35 "	79	790		
Mid-depth	78	2 22 "	79			
	81	2 41 "	79			
	84	2 59 "	79			
	87	3 18 "	79	(3 samples)		
	90	3 37 "	79	790		
Bottom	79	2 24 "	74			
	82	2 43 "	74			
	85	3 01 "	74			
	88	3 20 "	74	(3 samples)	(10 samples)	(20 samples)
	91	3 40 "	74	740	773	67%
					E, 44	P 20

Subject: Disposal Methods Division — File No. 205
New York Harbor Dissolved Oxygen in DH EAST RIVER — Acc. No. IH377
Average % of Saturation from Cross Sections AT THROGGS NECK — Sheet 1 of 1 Sheets 2
Computed by Gaff — Checked by — Date Jan 10 10-2.

Date of Collection Oct 25 1911 WW Sec I 8th AM

	Sample No	Time	% of Saturation	Average Per cent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current (W→E)						
Depth 1 Ft.	2173	730 AM	71			
	2176	742 "	72			
	2179	758 "	72			
	2203	320 PM	85			
	2212	342 "	87			
	2215	353 "	87			
	2218	406 "	76			
	2221	512 "	78	(8 samples)		
	2224	525 "	78	78.4%		
Mid-depth	2174	732 AM	79			
	2177	744 "	80			
	2180	757 "	81			
	2210	332 PM	85			
	2213	345 "	87			
	2216	357 "	87			
	2219	502 "	85			
	2222	514 "	87	(8 samples)		
	2225	527 "	87	84.2		
Bottom	2175	732 AM	78			
			same as Mid-depth	(8 samples)	(17 samples)	
	2226	538 PM	87	84.2	82.3%	
Ebb Current (W←E)	see sheet 2					

G 44 P 31

Disposal Matters - Division — File No. 205
New York Harbor Dissolved Oxygen in PPM EAST RIVER Case No. IM 580
Average C.C. per Liter. From Cross-Sections AT CLASON POINT Dated Jan 10 19[illegible]
Computed by: C.L.M. Checked by:

Date of Collection: June 30 1911 Flow Gen. I 11[illegible] AM Ebb 5[illegible] PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter		
				Each Current		Both Currents
				Each Depth	All Depths	All Depths
Flood Current (from ~~[illegible]~~)						
Depth 1 Ft	53	11:04 AM	3.43			
	54	11:55 "	3.43			
	59	11:46 "	3.11			
	63	11:04 PM	3.11	(2 samples)		
	65	10:56 "	3.11	3.24		
Mid-depth	56	11:02 AM	3.57			
	57	11:57 "	3.57			
	60	11:48 "	3.11			
	63	11:06 PM	3.11	(2 samples)		
	66	10:58 "	3.57	3.21		
Bottom	55	11:06 AM	3.11			
	58	11:50 "	3.11			
	61	11:50 "	3.11			
	64	11:10 PM	3.11	(3 samples)	(5 samples)	
	67	10:50 "	3.57	3.14	3.30	
Ebb Current (~~[illegible]~~ to ~~[illegible]~~)						
Depth 1 Ft	77	2:50 "	4.33			
	80	2:59 "	4.33			
	83	3:27 "	4.33			
	86	3:14 "	4.33	(3 samples)		
	89	3:35 "	4.33	4.33		
Mid-depth	78	2:53 "	4.33			
	81	3:41 "	4.33			
	84	3:59 "	4.33			
	87	3:18 "	4.33	(3 samples)		
	90	3:37 "	4.33	4.33		
Bottom	79	2:54 "	4.05			
	82	3:43 "	4.05			
	85	3:01 "	4.05			
	88	3:20 "	4.05	(3 samples)	(3 samples)	(10 samples)
	91	3:40 "	4.05	4.05	4.14	3.72
					4.77	3.32

Chemical Methods - Dilution
Sodium Hydrosulphite Dissolved Oxygen in the EAST RIVER
Average % of Saturation - from Cross Section AT LAWRENCE PT
Draft

Date Jan 3

Date of Collection July 18 1911 Low Water I 7:17 AM High Water I 13:37 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depths	Each Current All Depths	Both Currents All Depths
Flood Current Depths 1 Ft	416	10:00 AM	70 %			
	421	10:05 "	86			
	426	10:40 "	89			
	431	11:00 "	96			
	436	11:05 "	94			
	441	11:17 PM	84			
	446	1:09 "	84			
	451	1:28 "	86			
	456	1:46 "	84			
	461	2:30 "	88			
	466	2:50 "	86			
	471	3:10 "	86			
	476	3:30 "	86			
	481	3:48 "	86	(2 Readings)		
	486	4:00 "	84	85.4%		
Mid-ebb Depth	419	10:11 AM	89			
	424	10:35 "	89			
	429	10:45 "	89			
	434	11:31 "	86			
	439	11:34 "	86			
	444	11:38 PM	86			
	449	1:01 "	84			
	454	1:24 "	86			
	459	1:49 "	86			
	464	2:21 "	84			
	469	2:51 "	86			
	474	3:11 "	86			
	479	3:31 "	84			
	484	3:50 "	86	(2 Readings)		
	489	4:10 "	84	85.5		
Bottom - No sample?				85.90	85.52	

Subject: Disposal Methods Division — File No 205
How Can Hanson Dissolved Oxygen in 1911 — EAST RIVER — File No 1M349
Average % of Saturation - from Cross Sections — At LAWRENCE Pt — Sheet 2 for 3 Sheets
Computed by: E.L.H. — Checked by: — Date January 3 1912

Date of Collection July 18, 1911 Low Gauge I 7:12 AM High Gauge I 12 53 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation — Each Current — Each Depths	Each Current — All Depths	Both Currents — All Depths
Flood Current (Incoming)						
Depth 1 Ft. from Sheet 1				(1 sample) 564%		
Mid-depth "	—			(1 sample) 555		
Bottom	456	10:30 AM	59%			
	463	10 44 "	59			
	464	10 58 "	59			
	459	11 32 "	56			
	458	11 46 "	56			
	455	12 30 PM	59			
	438	1 08 "	54			
	441	1 26 "	56			
	444	1 49 "	56			
	447	2 33 "	54			
	450	2 52 "	54			
	453	3 13 "	54			
	456	3 33 "	54			
	459	3 48 "	54	(2 samples)	(2 samples)	
	462	4 03 "	54	560	556%	
Ebb Current (no complete Data)						
				2.99	P 34	

Subject: Disposal Metters- Dilution File No 205
New York Harbor Dissolved Oxygen in PPM EAST RIVER Acc. No 14381
Average C.C. per Liter. from Cross-Sections AT LAWRENCE PT Sheet 1 for in Case 2
Computed by: ELM. Checked by: Date Jan/10 19 32

Date of Collection: July 18 1931. L.W. G.T. 7:0 AM H.W. 12:52 PM

	Sample No.	Time	Oxygen CC per Liter	Averages C C per Liter		
				Each Current		Both Currents All Depths
				Each Depth	All Depths	
Flood Current						
Depth 1 Ft	419	10:10 AM	3.24			
	421	10:25 "	3.24			
	424	10:45 "	3.24			
	427	11:30 "	3.09			
	430	11:53 "	3.09			
	433	12:17 PM	3.09			
	436	1:00 "	2.95			
	439	1:23 "	2.95			
	442	1:46 "	2.95			
	445	2:10 "	2.95			
	448	2:30 "	2.95			
	451	3:10 "	2.95			
	454	3:30 "	2.95			
	457	3:45 "	2.95	(Flooding)		
	460	4:00 "	2.95	3.04		
Mid depth	419	10:12 AM	3.24			
	422	10:26 "	3.24			
	425	10:44 "	3.24			
	428	11:31 "	3.09			
	431	11:54 "	3.09			
	434	12:18 PM	3.09			
	437	1:01 "	2.95			
	440	1:24 "	2.95			
	443	1:47 "	2.95			
	446	2:11 "	2.95			
	449	2:31 "	2.95			
	452	3:11 "	2.95			
	455	3:31 "	2.95			
	458	3:46 "	2.95	(Flooding)		
	461	4:01 "	3.09	3.05		
				3.09	3.07	
Bottom, see sheet 2.						

SUBJECT Disposal Methods - Dilution
New York Harbor Dissolved Oxygen in 1911 — East River
Average C.C. per Liter. from Cross-Sections — at Lawrence Pt
COMPUTED BY Cleft. CHECKED BY
FILE NO 203
ACC NO 1H382
SHEET 2 TOT IN COMP 2
DATE Jun. 10 12

Date of Collection July 18, 1911 LW Gov I 7¹⁷ AM H/W 12²² PM

	Sample No	Time	Oxygen CC per Liter	Averages CC per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Flood Current						
Depth 1 Ft see sheet 1				(55 samples) 3.04		
Mid-depth	"			(55 samples) 3.05		
Bottom	420	10 18 AM	3.14			
	423	10 26 "	3.14			
	426	10 48 "	3.14			
	429	11 33 "	3.09			
	432	11 56 "	3.09			
	435	12 20 PM	3.14			
	438	1 03 "	2.95			
	441	1 26 "	3.09			
	444	1 49 "	3.09			
	447	2 33 "	2.95			
	450	2 53 "	2.95			
	453	3 18 "	2.95			
	456	3 33 "	2.98			
	459	3 48 "	2.95	(55 samples)	(165 samples)	
	462	4 03 "	3.09	3.07	3.05	
Ebb Current, no sample taken						
					E. 44	3.26

SUBJECT Special Memos Dilution FILE NO 205
New York Harbor Dissolved Oxygen in 1911 EAST RIVER ACC NO 1H367
Average % of Saturation from Cross Sections AT LAWRENCE PT SHEET 1 TOT IN COMP 2
COMPUTED BY L.L.H. CHECKED BY DATE Jan 8 1912
MADE IN CONNECTION WITH

Date of Collection, Oct 11, 1911 H.W. Gov I 9[59] AM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current						
Depth 1 ft	1894	7 50 AM	55%			
	1897	7 58 "	55			
	1900	8 06 "	56			
	1903	10 00 "	52			
	1906	10 08 "	52			
	1909	10 16 "	53			
	1912	12 00 M	51			
	1915	12 08 PM	51	(9 samples)		
	1918	12 16 "	52	53 0%		
Mid-depth	1895	7 52 AM	55			
	1898	8 00 "	56			
	1901	8 08 "	56			
	1904	10 02 "	55			
	1907	10 10 "	57			
	1910	10 18 "	55			
	1913	12 02 PM	54			
	1916	12 10 "	56	(9 samples)		
	1919	12 18 "	55	55 3		
Bottom	1896	7 54 AM	55			
	⋮	⋮	Same as Mid-depth	(9 samples)	(27 samples)	
	1920	12 20 PM	55	55 3	54 5 0	
Ebb Current see sheet 2						
				Ex 44 p 37		

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK

SUBJECT: DISPOSAL METHODS Dilution — FILE NO. 205
NEW YORK HARBOR Dissolved Oxygen in 1911 — EAST RIVER ACC. NO. 11368
Average % of Saturation - from Cross Sections — AT LAWRENCE POINT SHEET 2 TO 2 CODE 2
COMPUTED BY: C.A.H. — CHECKED BY: — DATE: Jan 8 19 12

MADE IN U.S.A. BY KEUFFEL & ESSER CO. N.Y.

Date of Collection Oct 11 1911 HW Gov I 9⁵⁹ AM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Flood Current (see sheet)					(27 samples) 54.5%	
Ebb Current						
Depth 15ft	1921	2.00 PM	55%			
	1924	2.08 "	55			
	1927	2.16 "	55			
	1930	4.00 "	59			
	1933	4.08 "	62			
	1936	4.16 "	60			
	1939	5.00 "	59			
	1942	5.08 "	62	(9 samples)		
	1945	5.16 "	60	58.6%		
Mid depth	1922	2.02 "	55			
	1925	2.10 "	57			
	1928	2.18 "	55			
	1931	4.02 "	62			
	1934	4.10 "	64			
	1937	4.18 "	63			
	1940	5.02 "	62			
	1943	5.10 "	64	(9 samples)		
	1946	5.18 "	63	60.6%		
Bottom	1923	2.04 "	55			
			Same as Mid depth	(9 samples)	(9 samples)	(54 samples)
	1947	5.20	63	60.6	59.9	57.5%
				E. 77	P. 38	

SUBJECT DISPOSAL METHODS- Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911 EAST RIVER
Average C.C. per Liter. from Cross-Sections AT LAWRENCE POINT
COMPUTED BY CHECKED BY
MADE IN CONNECTION WITH

FILE NO 205
ACC NO 11405
SHEET 1 TO 2 CONT 2
DATE Jan 15 1912

Date of Collection Oct. 11 1911 HW Gov I 9^50 AM

	Sample No.	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents & All Depths
Flood Current						
Depth 1 Ft	1894	7.50 AM	328			
	1897	7.58 "	327			
	1900	8.06 "	333			
	1903	10 00 "	314			
	1906	10 08 "	312			
	1909	10 16 "	319			
	1912	12 00 M	314			
	1915	12 08 PM	312	(9 samples)		
	1918	12 16 "	319	320		
Mid-depth	1895	7.52 AM	328			
	1898	8 00 "	327			
	1901	8.08 "	333			
	1904	10 02 "	328			
	1907	10 10 "	341			
	1910	10 18 "	333			
	1913	12 02 PM	328			
	1916	12 10 "	341	(9 samples)		
	1919	12 18 "	333	332		
Bottom	1896	7.54 AM	328			
			Same as Mid-depth	(9 samples)	(17 samples)	
	1920	12 20 PM	333	332	328	
Ebb Current see sheet 2				F. 99	P 39.	

SUBJECT: DISPOSAL METHODS - Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911 EAST RIVER
Average C.C. per Liter. from Cross-Sections AT LAWRENCE POINT
COMPUTED BY: E.E.M. CHECKED BY:
MADE IN CONNECTION WITH:

FILE NO. 205
ACC. NO. IH 406
SHEET 2 TO 2 SHEETS
DATE Jan. 15 1912

Date of Collection, Oct. 11 1911 HW Gov I 9 AM

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter		
				Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current, see sheet 1					(21 samples) 328	
Ebb Current						
Depth 1 Ft	1921	2 00 PM	3.28			
	1924	2 08 "	3.29			
	1927	2 16 "	3.33			
	1930	4 00 "	3.55			
	1933	4 08 "	3.70			
	1936	4 16 "	3.61			
	1939	5 00 "	3.55			
	1942	5 08 "	3.70	(9 samples)		
	1945	5 16 "	3.61	351		
Mid-depth	1922	2 02 "	3.28			
	1925	2 10 "	3.41			
	1928	2 18 "	3.33			
	1931	4 02 "	3.69			
	1934	4 10 "	3.84			
	1937	4 18 "	3.75			
	1940	5 02 "	3.69			
	1943	5 10 "	3.84	(9 samples)		
	1946	5 18 "	3.75	362		
Bottom	1923	2 04 "	3.28			
			Same as Mid depth			
	1947	5 20 "	3.75	(9 samples) 362	(327 samples) 358	(54 samples) 343

Ex 99 P 40

U.S. ARMY DISPOSAL MATERIALS Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911
Average % of Saturation from Cross Sections
COMPUTED BY JHH CHECKED BY

MOUTH OF EAST RIVER

FILE NO 205
ACC. NO. 11347
SHEET 1 TOT. IN COMP. 2.
DATE Jan. 4, 1912

Date of Collection July 27 1911 HW Gov I 9²⁰ AM LW Gov I 3³⁶ PM

	Sample No	Time	% of Saturation	Average Percent of Saturation: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depths
Flood Current						
Depth 1 Ft	598	930 AM	54%			
	601	938 "	55			
	604	946 "	59			
	607	954 "	57	(5 samples)		
	610	1002 "	55	56.0%		
Mid-depth	599	931 "	54			
	602	939 "	55			
	605	947 "	62			
	608	955 "	61	(5 samples)		
	611	1003 "	55	57.4		
Bottom	600	932 "	54			
	603	941 "	55			
	606	949 "	62			
	609	957 "	61	(5 samples)	(15 samples)	
	612	1005 "	55	57.4	56.9%	
Ebb Current see sheet 2						

E. 99 P 41

SUBJECT DISPOSAL METHODS Dilution
New York Harbor Dissolved Oxygen in 1911 MOUTH OF
Average % of Saturation - from Cross Sections EAST RIVER
COMPUTED BY GAH. CHECKED BY
MADE IN CONNECTION WITH

FILE NO 205
ACC. NO. 1H348
SHEET 2 TOT IN CONN 2.
DATE Jan 4 1912

Date of Collection, July 27 1911 H W Gov I 9²³ AM L W Gov. I 3³⁵ PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current: Each Depth	Each Current: All Depths	Both Currents & All Depths
Flood Current see sheet 1					56.9% (48 samples)	
Ebb Current						
Depth 1 Ft	613	12 00 M	52%			
	616	12 08 PM	53			
	619	12 16 "	57			
	622	12 24 "	55			
	625	12 32 "	53			
	628	2 00 "	49			
	631	2 08 "	51			
	634	2 16 "	54			
	637	2 24 "	52	(10 samples)		
	640	2 32 "	50	52.6%		
Mid-depth	614	12 01 "	52			
	617	12 09 "	53			
	620	12 17 "	60			
	623	12 25 "	58			
	626	12 33 "	53			
	629	12 01 "	49			
	632	2 09 "	51			
	635	2 17 "	56			
	638	2 25 "	52	(10 samples)		
	641	2 33 "	50	53.4%		
Bottom	615	12 03 "	52			
	618	12 11 "	53			
	621	12 19 "	60			
	624	12 27 "	58			
	627	12 35 "	53			
	630	2 03 "	49			
	633	2 11 "	51			
	636	2 19 "	56			
	639	2 27 "	52	(10 samples)	(38 samples)	(48 samples)
	642	2 35 "	50	53.4	53.1	55%
					Ex 99	P 42

Subject: Disposal Methods - Dilution
New York Harbor Dissolved Oxygen in PPM
Average C.C. per Liter. From Observations
Computed by GAH.
Checked by

Mouth of EAST RIVER

File No 205
Acc. No 11385
Sheet 1 Tot. in Group 2
Date Jan. 11 1912.

Date of Collection July 27 1911 H.W. Gov I 01 AM L.W. 3 55 PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter		
				Each Current		Both Currents & All Depths
				Each Depth	All Depths	
Flood Current						
Depth 1 Ft.	596	9 30 AM	2 97			
	601	9 38 "	3 03			
	604	9 46 "	3 14			
	607	9 54 "	3 14	(3 samples)		
	610	10 02 "	3 01	3 08		
Mid-depth	598	9 31 "	2 97			
	602	9 39 "	3 03			
	605	9 47 "	3 38			
	608	9 55 "	3 29	(3 samples)		
	611	10 03 "	3 01	3 14		
Bottom	600	9 33 "	2 97			
	603	9 41 "	3 03			
	606	9 49 "	3 50			
	609	9 57 "	3 29	(3 samples)	(6 samples)	
	612	10 05 "	3 01	3 14	3 12	
Ebb Current, see sheet 2.						
				E = 99	P 4.1	

Subject: DISPOSAL METHODS- Dilution
New York Harbor Dissolved Oxygen in 1911 MOUTH OF EAST RIVER
Average C.C. per Liter. from Cross-Sections.
Computed by BELL. Checked by
Dwg No 205
Acc No 1H386
Sheet 2 of 11 Sheets
Date Jan 11 1913

Date of Collection. July 27. 1911 H.W. Gov I 9.38 AM L.W. 3.29 PM

	Sample No	Time	Oxygen CC per Liter	Averages C.C. per Liter	
				Each Current- Each Depth	All Depths Both Currents All Depths
Flood Current, see sheet 1					(4 samples) 3.12
Ebb Current					
Depth 1 Ft	613	12.00 M.	2.81		
	616	12.08 PM	3.90		
	619	12.16 "	3.09		
	622	12.24 "	3.00		
	625	12.32 "	3.08		
	628	2.00 "	3.70		
	631	2.08 "	3.74		
	634	2.16 "	3.95		
	637	2.24	3.86	(6 samples)	
	640	2.32 "	2.74	2.87	
Mid depth	614	12.01 "	2.91		
	617	12.09 "	3.20		
	620	12.17 "	3.24		
	623	12.25 "	3.14		
	626	12.33 "	3.38		
	629	2.01 "	3.30		
	632	2.09 "	2.76		
	635	2.17 "	3.09		
	638	2.25 "	2.86	(4 samples)	
	641	2.33 "	2.76	2.91	
Bottom	615	12.03 "	2.81		
			Same as Mid depth	(2 samples)	(10 samples) (45 samples)
	642	2.35 "	2.74	2.91	2.90 3.01

Ex. 99. P. 44

Project Disposal Mattoons Dilution
New York Harbor Dissolved Oxygen in 1911 Mouth of
Average % of Saturation from Cross Sections EAST RIVER
Computed by Lamb Checked by
Plate No 205
Acc No 111349
Sheet 1 Tot. in Group 2
Date Jan 4 1912.

Date of Collection: Aug. 3 1911 L.W. Gov I 9^07 AM H.W. Gov I 3^13 PM

	Sample No	Time	% of Saturation	Averages Percent of saturation Each Current Each Depth	All Depths
Ebb Current					
Depth 1 Ft	768	9 10 AM	90%		
	771	9 18 "	91		
	774	9 26 "	84		
	777	9 34 "	93	(4 samples)	
	780	9 42 "	89	91.6%	
Mid-Depth	769	9 11 "	85		
	772	9 19 "	86		
	775	9 27 "	87		
	778	9 35 "	86	(5 samples)	
	781	9 43 "	93	85.2	
Bottom	770	9 13 "	88		
	773	9 21 "	86		
	776	9 29 "	87		
	779	9 37 "	88	(5 samples)	(14 samples)
	782	9 45 "	93	88.2	86.6%
Flood Current see sheet 2.					
				6.39	P.M.

Subject: Chemical Methods Division — Plate No. 2C 5
Newton Harbor Dissolved Oxygen in PPM — Mouth of — Case No. 6M 88 C
Average % of Saturation from Cross Sections — EAST RIVER — Sheet 2 of 4 Sheets 2.
Compared by: Lown — Checked by: — Date Jan. 4 19 42

Date of Collection: Aug 3 1941 — Low Water 9:17 AM — High Water 3:12 PM

	Sample No	Time	% of Saturation	Average % Amount of Saturation Ebb Current		Both Currents All Depths
				East Depth	All Depths	
Ebb Current commenced					54.0% (3 samples)	
Flood Current Depth in Ft	783	11:05 AM	54%			
	784	12:03 PM	55			
	789	12:11 "	56			
	792	12:19 "	55			
	795	12:27 "	50			
	798	12:40 "	59			
	801	2:48 "	60			
	804	2:56 "	61			
	807	3:04 "	60	(2 samples)		
	810	3:12 "	60	57.0%		
Mid depth	784	11:54 AM	54			
	787	12:49 PM	55			
	790	12:15 "	54			
	793	12:20 "	53			
	796	12:28 "	53			
	799	2:41 "	59			
	802	2:49 "	60			
	805	2:57 "	61			
	808	3:05 "	60	(2 samples)		
	811	3:13 "	60	57.3		
Bottom	785	11:58 AM	54			
	788	12:46 PM	55			
	791	12:14 "	54			
	794	12:33 "	55			
	797	12:31 "	53			
	800	2:43 "	59			
	803	2:51 "	60			
	806	2:59 "	61			
	809	3:07 "	60	(2 samples)	(12 samples)	(18 samples)
	812	3:15 "	60	57.5	57.2	56.7
					4.99	P4u

Subject: Disposal Methods- Dilution
New York Harbor Dissolved Oxygen in 1911
Average C.C. per Liter from Good Sections
Compiled by: Edith M. Checked by:

Mouth of EAST RIVER

File No. 205
Acc. No. 1N387
Sheet 1 of 2 Sheets
Date June 11 1913

Date of Collection Aug 2, 1911 Low Water 5 47 AM High 3 10 PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current Each Depth	Each Current All Depths	Both Currents in All Depths
Ebb Current						
Depth 12'	768	8:10 AM	2.70			
	771	9:15 "	3.76			
	774	9:26 "	3.49			
	777	9:34 "	3.84	(Incomplete)		
	780	9:42 "	2.76	2.80		
Mid-depth	769	9:11 "	2.37			
	772	9:19 "	3.13			
	775	9:27 "	3.49			
	778	9:35 "	3.00	(Incomplete)		
	781	9:43 "	2.85	2.99		
Bottom	770	9:13 "	2.97			
	773	9:21 "	3.43			
	776	9:29 "	3.49			
	779	9:37 "	3.00	(2 samples)	(3 samples)	
	782	9:45 "	2.88	2.99	2.91	
Flood Current	see sheet 2.					
				E. 2.94	F. 2.7	

Subject: Disposal Methods - Dilution
Rpt. for Harbor Dissolved Oxygen in PPI
Average CC per liter. From Cross-Sections
Computed by: W.M.A. Checked by:

MOUTH OF EAST RIVER

File No. 205
Acc. No. IM 388
Report 2 for in Order 2.
Date Jan 11 1913

Date of Collection Aug 3 1911 Low Water 8⁰⁷ AM High 5⁵⁹ PM

	Sample No.	Time	Oxygen CC per Liter	Averages CC per Liter: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depths
East Current (to meet)					(Average) 2 93	
Flood Current						
Depth 15f:	783	11 55 AM	2 97			
	786	12 42 PM	3 03			
	789	12 11 "	3 09			
	792	12 19 "	3 00			
	795	12 33 "	2 76			
	798	2 46 "	3 24			
	801	2 48 "	3 31			
	804	2 56 "	3 30			
	807	3 04 "	3 29	(Average)		
	810	3 12 "	3 00	3 13		
Mid depth	784	11 56 AM	2 97			
	787	12 04 PM	3 03			
	790	12 13 "	3 09			
	793	12 20 "	3 00			
	796	12 26 "	2 89			
	799	2 41 "	3 24			
	802	2 49 "	3 41			
	805	2 57 "	3 38			
	808	3 05 "	3 29	(Average)		
	811	3 13 "	3 29	3 19		
Bottom	785	11 58 AM	2 97			
			Same as Mid-depth			
	812	3 13 PM	3 29	(Average) 3 15	(Average) 3 14	(Average) 3 04
				E. 99	P 45	

DARK PAGE

Subject: Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911
Average % of Saturation from Cross Sections
Computed by Bath. Checked by

File No 205
Acc. No 1H360
Mouth of EAST RIVER Sheet 1 of 2
Date Jan 6, 1912

Date of Collection Sept 29 1911, LW Gov I 6.57 AM, HW 12.50 PM, LW 7.17 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation. Each Current: Each Depth	Each Current: All Depths	Both Currents All Depths
Ebb Current						
Depth 1 Ft	1684	7.30AM	49%			
	1687	7.38 "	49			
	1690	7.46 "	51			
	1693	7.54 "	50			
	1696	8.02 "	49			
	1744	4.30PM	51			
	1747	4.38 "	52			
	1750	4.46 "	54			
	1753	4.54 "	53			
	1756	5.02 "	52			
	1759	5.10 "	49			
	1762	5.26 "	52			
	1765	5.13 "	54			
	1768	5.50 "	52	(Elsewhere)		
	1771	6.07 "	49	51.0%		
Mid depth	1693	7.32AM	51			
	1688	7.40 "	52			
	1691	7.48 "	54			
	1694	7.56 "	53			
	1697	8.06 "	52			
	1745	4.32PM	51			
	1748	4.40 "	50			
	1751	4.48 "	54			
	1754	4.56 "	53			
	1757	5.06 "	52			
	1760	5.01 "	51			
	1763	5.07 "	53			
	1766	5.14 "	54			
	1769	6.21 "	53	(Elsewhere)		
	1772	6.28 "	52	52.9		
Bottom	1696	7.34AM	51			
	↓	↓	(Same as Mid depth)			
	1773	6.30 PM	52	52.9	52.8%	
				Co. 99	P. 49	

Flood Current See sheet 2.

3945

BLEED THRU

3946

SUBJECT DISPOSAL METHODS Dilution
New York Harbor Dissolved Oxygen in 1911 — MOUTH OF EAST RIVER
Average % of Saturation - from Cross Sections
COMPUTED BY EAH. CHECKED BY
MADE IN CONNECTION WITH

FILE NO 205
ACC. NO. IH361
SHEET 2 TOT. IN COMP 2
DATE Jan 6 1912

Date of Collection, Sept 29, 1911 LW Gov I 6^27 AM HW 12^23 PM LW 7^27 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Ebb Current, see sheet 1					52.3% (46 samples)	
Flood Current Depth 1 Ft	1699	9 30 AM	53%			
	1702	9 38 "	54			
	1705	9 46 "	56			
	1708	9 54 "	55			
	1711	10 02 "	48			
	1714	12 30 PM	55			
	1717	12 40 "	56			
	1720	12 49 "	59			
	1723	12 57 "	58			
	1726	1 05 "	54			
	1729	2 30 "	58			
	1732	2 38 "	59			
	1735	2 46 "	59			
	1738	2 54 "	58	(15 samples)		
	1741	3 02 "	56	55.9%		
Mid-depth	1700	9 32 AM	55			
	1703	9 40 "	56			
	1706	9 48 "	56			
	1709	9 56 "	55			
	1712	10 04 "	51			
	1715	12 32 PM	58			
	1718	12 42 "	59			
	1721	12 51 "	59			
	1724	12 59 "	58			
	1727	1 07 "	56			
	1730	2 32 "	58			
	1733	2 40 "	59			
	1736	2 48 "	59			
	1739	2 56 "	58	(15 samples)		
	1742	3 04 "	56	56.9		
Bottom	1701	9 34 PM	55			
	⋮	⋮	Same as Mid-depth	(15 samples)	(45 samples)	(90 samples)
	1743	3 06 PM	56	56.9 6 × 59	56.6 P 50	54%

Subject: DISPOSAL METHODS- Dilution — File No 205
New York Harbor Dissolved Oxygen in 1911 — MOUTH OF EAST RIVER — Acc No 398
Average C.C. per Liter. from Cross-Sections — Sheet 1 of 2 Sheets
Computed by Gelli. Checked by — Date Jan 12 1912.

Date of Collection, Sept 29 1911 LWGov I 6.47 AM HW 12.53 PM LW 7.31 PM

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Ebb Current						
Depth 1 Ft	1684	7 30 AM	2 73			
	1687	7 38 "	2 80			
	1690	7 46 "	2 92			
	1693	7 54 "	2 84			
	1696	8 02 "	2 79			
	1744	4 30 PM	2 87			
	1747	4 38 "	2 94			
	1750	4 46 "	3 04			
	1753	4 54 "	3 00			
	1756	5 02 "	2 92			
	1759	6 00 "	2 73			
	1762	6 06 "	2 94			
	1765	6 13 "	3 04			
	1768	6 20 "	3 00	(10 samples)		
	1771	6 27 "	2 79	2 89		
Mid-depth	1685	7 32 AM	2 87			
	1688	7 40 "	2 94			
	1691	7 48 "	3 04			
	1694	7 56 "	3 00			
	1697	8 04 "	2 92			
	1745	4 32 PM	2 87			
	1748	4 40 "	3 08			
	1751	4 48 "	3 13			
	1754	4 56 "	3 12			
	1757	5 04 "	2 92			
	1760	6 01 "	2 87			
	1763	6 07 "	2 94			
	1766	6 14 "	3 04			
	1769	6 21 "	3 00	(9 samples)		
	1772	6 28 "	2 92	2 98		
Bottom	1686	7 36 AM	2 87			
			Same as Mid depth	(9 samples)	(45 samples)	
	1773	6 30 PM	2 91	2 98	2 95	
				C 99	P 91	
Flood Current see sheet 2						

Subject: Disposal Methods- Dilution — File No. 2c 5
New York Harbor Dissolved Oxygen in 1911 — Acc. No. 1H399
Average C.C. per Liter. from Cross-Sections — Mouth of East River — Sheet 2 of 2 Sheets in Group 2
Computed by CHH. — Checked by — Date Jun 12 1912

Date of Collection, Sept 29 1911 Low Water 1 a.m. 27 AM High Water 12 27 PM Low Water 7 27 PM

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Ebb Current (see sheet)					2 95 (3 samples)	
Flood Current						
Depth 1 Ft	1699	9 30 AM	3 01			
	1702	9 38 "	3 00			
	1705	9 46 "	3 16			
	1708	9 56 "	3 17			
	1711	10 02 "	2 93			
	1714	12 36 PM	3 14			
	1717	12 40 "	3 19			
	1720	12 49 "	3 33			
	1723	12 57 "	3 27			
	1726	1 05 "	3 06			
	1729	2 30 "	3 26			
	1732	2 38 "	3 31			
	1735	2 46 "	3 33			
	1738	2 54 "	3 27	(8 samples)		
	1741	3 02 "	3 19	3 17		
Mid-depth	1700	9 33 AM	3 14			
	1703	9 40 "	3 19			
	1706	9 48 "	3 19			
	1709	9 56 "	3 12			
	1712	10 04 "	2 93			
	1715	12 32 PM	3 26			
	1718	12 42 "	3 34			
	1721	12 51 "	3 33			
	1724	12 59 "	3 27			
	1727	1 07 "	3 19			
	1730	2 32 "	3 28			
	1733	2 40 "	3 26			
	1736	2 48 "	3 33			
	1739	2 56 "	3 27	(10 samples)		
	1742	3 04 "	3 13	3 25		
Bottom	1701	9 34 AM	3 14			
			Same as Mid-depth	(10 samples)	(20 samples)	(30 samples)
	1743	3 06 PM	3 19	3 23	3 21	3 08
				E. 99	P. 52	

SUBJECT Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911 EAST END OF FILE NO 209
Average % of Saturation - from Cross Sections KILL VAN KULL ACC NO 1H362
SHEET 1 TOT IN COMP 2
COMPUTED BY Blatt. CHECKED BY DATE Jan 8 19 12
SHEET IN CONNECTION WITH

Date of Collection Oct. 4 1911 HW Gov I 5^43 AM LW II^13 AM HW 5^20 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents & All Depths
Flood Current						
Depth 1 ft	1774	7.30 AM	69 %			
	1777	7.39 "	71			
	1780	7.48 "	70			
	1801	1.30 PM	69			
	1804	1.39 "	71			
	1807	1.48 "	75			
	1810	3.30 "	70			
	1813	3.39 "	72			
	1816	3.48 "	73			
	1819	5.30 "	73			
	1822	5.39 "	77	(4 samples)		
	1825	5.48 "	78	72.5 %		
Mid-depth	1775	7.32 AM	74			
	1778	7.41 "	76			
	1781	7.50 "	75			
	1802	1.32 PM	73			
	1805	1.41 "	76			
	1808	1.50 "	77			
	1811	3.32 "	76			
	1814	3.41 "	77			
	1817	3.50 "	76			
	1820	5.32 "	80			
	1823	5.41 "	82	(3 samples)		
	1826	5.50 "	81	76.9		
Bottom	1776	7.34 AM	79			
	1779	7.43 "	81			
	1782	7.52 "	80			
	1803	1.34 PM	73			
	1806	1.43 "	76			
	1809	1.52 "	77			
	1812	3.34 "	76			
	1815	3.43 "	77			
	1818	3.52 "	73			
	1821	5.34 "	80			
	1824	5.43 "	82	(3 samples)	(36 samples)	
	1827	5.52 "	81	77.9	75.8%	

Cf. 99 P 53

SUBJECT Disposal Methods - Dilution
New York Harbor Dissolved Oxygen in 1911 East End of Kill Van Kull
Average % of Saturation - from Cross Sections
COMPUTED BY Leff CHECKED BY
DONE IN CONNECTION WITH
File No 205
Book No 1H363
Sheet 2 Tot in Comp 2.
Date Jun 8 1912

Date of Collection, Oct 4 1911 HW Gov I 5^03 AM LW H ? AM HW S 2^0 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation: Each Current — Each Depth	Each Current — All Depths	Both Currents — All Depths
					(24 samples)	
Flood Current, see sheet 1					75 8%	
Ebb Current						
Depth 1 ft	1783	9 30 AM	73			
	1786	9 39 "	75			
	1789	9 48 "	74			
	1792	11 30 "	68			
	1795	11 39 "	71	(6 samples)		
	1798	11 48 "	70	71 8%		
Mid-depth	1784	9 32 "	73			
	1787	9 41 "	75			
	1790	9 50 "	76			
	1793	11 32 "	73			
	1796	11 41 "	76	(6 samples)		
	1799	11 50 "	74	74 8		
Bottom	1785	9 34 "	73			
	1788	9 43 "	75			
	1791	9 52 "	76			
	1794	11.34	73			
	1797	11.43	76	(6 samples)	(12 samples)	(24 samples)
	1800	11.52 "	74	74 5	73 6	75 7%
				E 99	P 84	

SUBJECT: DISPOSAL METHODS- Dilution
New York Harbor Dissolved Oxygen in 1911 EAST END OF
Average C.C. per Liter. From Cross-Sections KILL VAN KULL
COMPUTED BY: ELLH. CHECKED BY:

FILE NO. 205
ASS. NO. 1M400
SHEET 1 TOT. IN GROUP 2
DATE Jan 13 1913.

Date of Collection: Oct 4 1911 HWGI 8:11AM LWII:9AM HW 3:32PM

	Sample No.	Time	Oxygen C C per Liter	Averages C C per Liter		
				Each Current		Both Currents & All Depths
				Each Depth	All Depths	
Flood Current						
Depth 1Ft	1774	7:30 AM	4.10			
	1777	7:39 "	4.20			
	1780	7:48 "	4.17			
	1801	1:30 PM	4.10			
	1804	1:39 "	4.24			
	1807	1:48 "	4.44			
	1810	3:30 "	4.10			
	1813	3:39 "	4.17			
	1816	3:48 "	4.36			
	1819	5:30 "	4.39			
	1822	5:39 "	4.44	(9 samples)		
	1825	5:48 "	4.54	4.26		
Mid-depth	1775	7:33 AM	4.38			
	1778	7:41 "	4.49			
	1781	7:50 "	4.44			
	1802	1:33 PM	4.38			
	1805	1:41 "	4.35			
	1808	1:50 "	4.38			
	1811	3:32 "	4.30			
	1814	3:41 "	4.44			
	1817	3:50 "	4.40			
	1820	5:32 "	4.45			
	1823	5:41 "	4.72	(9 samples)		
	1826	5:50 "	4.49	4.51		
Bottom	1776	7:34 AM	4.45			
	1779	7:43 "	4.78			
	1782	7:52 "	4.92			
	1803	1:34 PM	4.38			
	1806	1:43 "	4.55			
	1809	1:52 "	4.38			
	1812	3:34 "	4.38			
	1815	3:43 "	4.44			
	1818	3:52 "	4.24			
	1821	5:34 "	4.45			
	1824	5:43 "	4.72	(9 samples)	(18 samples)	
	1827	5:52 "	4.49	4.57	4.45	

C. 59 P.

SUBJECT DISPOSAL METHODS- Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911 EAST END OF KILL VAN KULL
Average C.C. per Liter. from Quad-Sections
COMPUTED BY C.H.H. CHECKED BY
FILE NO 20.5
ACC. NO 1M401
SHEET 2 OF 2 SHEETS
DATE Jan 13 1912.

Date of Collection, Oct 4, 1911 HWGov I. 5^{50}AM LW11^{17}AM HW3^{52}PM

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents All Depths
Flood Current see sheet 1					(26 samples) 4.45	
Ebb Current						
Depth 1 Ft	1783	9 50AM	4.36			
	1786	9 35 "	44			
	1789	9 48 "	4.44			
	1792	11 50 "	4.10			
	1795	11 38 "	4.36	(6 samples)		
	1798	11 48 "	4.17	4.30		
Mid-depth	1784	9 32 "	4.38			
	1787	9 41 "	4.49			
	1790	9 50 "	4.58			
	1793	11 32 "	4.36			
	1796	11 41 "	4.56	(6 samples)		
	1799	11 50 "	4.44	4.47		
Bottom	1785	9 34 "	4.38			
	⋮	⋮	Same as Mid-depth			
	1800	11 52 "	4.44	(6 samples) 4.47	(12 samples) 4.41	(24 samples) 4.43
				& 99	P 04	

Subject: Disposal Methods Division
New York Harbor Dissolved Oxygen in 1911
Average % of Saturation from Cross Sections
Computed by Lee N.
Checked by

THE NARROWS

File No. 205
Acc. No. IH351
Sheet No. 101 to Comp
Date Jan 4, 1913

Date of Collection Aug. 9, 1911 HW Gov I 7⁴⁵ AM L.W Gov I. 2⁰⁷ PM.

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Averages Percent of Saturation Each Current All Depths	Averages Percent of Saturation Both Currents All Depths
Ebb Current						
Depth 1 Ft	876	9 40 AM	74%			
	879	9 56 "	76			
	882	10 00 "	76			
	885	11 40 "	64			
	888	12 00 M	66			
	891	12 16 PM	65			
	894	1 16 "	64			
	897	1 20 "	67	(9 samples)		
	900	1 36 "	66	68.7%		
Mid-depth	877	9 12 AM	79			
	880	9 32 "	82			
	883	10 02 "	82			
	886	11 42 "	69			
	889	12 02 PM	69			
	892	12 12 "	71			
	895	1 12 "	70			
	898	1 32 "	69	(9 samples)		
	901	1 52 "	69	73 3		
Bottom	878	9 44 AM	73			
	881	9 54 "	82			
	884	10 04 "	82			
	887	11 44 "	69			
	890	12 04 "	69			
	893	12 14 "	71			
	896	1 14 "	70			
	899	1 24 "	69	(9 samples)	(17 samples)	
	902	1 34 "	69	73 3	71.8%	
Flood Current no samples taken						
				Ex 93	P 57	

Subject: Disposal Methods- Dilution
New York Harbor Dissolved Oxygen in PPM
Average C.C. per Liter. from Good Sections
Computed by: E.L.M. Checked by:

THE NARROWS

Plate No 205
Acc. No 14389
Sheet No. of Cases
Date Jan 11 1913

Date of Collection Aug 9 1911 HW Gov. I. 7⁴³ AM LW 2⁴⁰ PM

	Sample No	Time	Oxygen CC per Liter	Averages C.C per Liter		
				Each Current		Both Currents & All Depths
				Each Depth	All Depths	
Ebb Current						
Depth 15'	876	9 40 AM	4.01			
	879	9.50 "	4.00			
	883	10.00 "	4.11			
	885	11.40 "	3.43			
	908	11 [illegible] AM	3.37			
	951	12 [illegible] PM	3.53			
	954	1.10 "	3.43			
	897	1.20 "	3.37	[illegible]		
	900	1.30 "	3.33	3.70		
Mid depth	877	9.42 AM	4.24			
	880	9.52 "	4.28			
	884	10.02 "	4.42			
	886	11.42 "	3.78			
	889	12.02 PM	3.70			
	892	12.12 "	3.83			
	895	1.12 "	3.78			
	898	1.22 "	3.70	[illegible]		
	901	1.32 "	3.48	3.93		
Bottom	878	9.46 AM	4.24			
	⋮	⋮	same as Mid depth	[illegible]	[illegible]	
	902	1.34 PM	3.68	3.93	3.84	
Flood Current, 22 Samples Taken				4.09	3.96	

Subject: Disposal Methods Division
New York Harbor Dissolved Oxygen in PPM
Average % of Saturation from Cross Sections
Computed by Swift

THE NARROWS

Plate No 205
Acc. No. IH564
Sheet 1 Ser. No. Class 3
Date Jan. 5 1931

Date of Collection Sept 26 1911 LW Gov I 4⁰ AM HW to Battery 10 AM LW 4 PM

	Sample No	Time	% of Saturation	Average % Percent of Saturation		
				Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current						
Depth 1 Ft	1474	6 30 AM	65 %			
	1477	6 30 -	67			
	1480	6 48 -	69			
	1483	6 57 -	68			
	1486	7 06 -	66			
	1489	8 30 -	83			
	1492	8 39 -	85			
	1495	8 48 -	85			
	1498	8 57 -	86			
	1501	9 06 -	84			
	1504	10 30 -	85			
	1507	10 39 -	87			
	1510	10 48 -	88			
	1513	10 57 -	89	(10 samples)		
	1516	11 06 -	89	78.7 %		
Mid depth	1475	6 22 -	68			
	1478	6 41 -	90			
	1481	6 50 -	90			
	1484	6 59 -	69			
	1487	7 08 -	69			
	1490	8 32 -	89			
	1493	8 41 -	91			
	1496	8 50 -	89			
	1499	8 59 -	90			
	1502	9 08 -	90			
	1505	10 32 -	89			
	1508	10 41 -	91			
	1511	10 50 -	89			
	1514	10 59 -	90	(9 samples)		
	1517	11 08 -	90	82.9		
Bottom	1476	6 34 -	68			
	1479		Same as Mid depth			
	etc.					
	1515			(10 samples)	(19 samples)	
	1518	11 10 -	90	82.9	81.8 %	
				6.90	9.00	

SUBJECT Disposal Methods Division
New York Harbor Dissolved Oxygen in 1911
Average % of Saturation from Cross Sections
COMPUTED BY E.A.H. CHECKED BY

THE NARROWS

FILE NO 205
ENG. NO 1H355
SHEET 2 OF 4 CROSS 3
DATE Jan 5 1912

Date of Collection Sept 26 1911 Low Water I 47 PM HIGH 10 30 AM LOW 67 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation		
				Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Ebb Current Depth 16?	1519	12 30 PM	85%			
	1522	12 38 "	87			
	1525	12 46 "	85			
	1528	12 57 "	85			
	1531	1 04 "	84			
	1534	2 30 "	77			
	1537	2 39 "	79			
	1540	2 48 "	77			
	1543	2 57 "	75			
	1546	3 06 "	77			
	1549	4 30 "	70			
	1552	4 39 "	73			
	1555	4 48 "	73			
	1558	4 57 "	70			
	1561	5 06 "	69			
	1564	6 00 "	65			
	1567	6 08 "	67			
	1570	6 16 "	69			
	1573	6 24 "	68	[illegible]		
	1576	6 32 "	66	75.0%		
			6.99	7.00		

Subject: Disposal Methods Division — File No. 205
New York Harbor Dissolved Oxygen in Rel — Acc. No. 111356
Average % of Saturation - from Cont. Sections — THE NARROWS — Sheet 3 of 4 Sheets 3
Computed by: Goff — Checked by: — Date: Jan 5 19 12

Date of Collection, Sept 26, 1911 LW Bkn 1 41 AM. HW 10 11 AM LW 4 37 PM

	Sample No	Time	% of Saturation	Average Percent of Saturation: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Flood Current (corrected)					(Incomplete) 81.6%	
Ebb Current				(Incomplete)		
Depth 1 Ft. from Bottom 2				78.0%		
Mid-depth	1520	12 32 PM	84.7%			
	1523	12 41 "	88			
	1526	12 50 "	89			
	1529	12 59 "	87			
	1532	1 08 "	88			
	1535	1 21 "	81			
	1538	3 41 "	80			
	1541	3 50 "	78			
	1544	3 59 "	74			
	1547	4 08 "	77			
	1550	4 32 "	70			
	1553	4 41 "	73			
	1556	4 50 "	73			
	1559	4 59 "	71			
	1562	5 08 "	73			
	1565	6 05 "	68			
	1568	6 16 "	69			
	1571	6 18 "	73			
	1574	6 26 "	71	(Incomplete)		
	1577	6 34 "	69	76.8%		
Bottom	1531	12 36 "	84			
	1534	12 43 "	88			
	etc		(Same as Mid-depth)			
	1573	6 28 "	71	(Incomplete)	(Incomplete)	(Incomplete)
	1576	6 36 "	69	74.8	76.2	79%
				6.9x	4.6	

SUBJECT: DISPOSAL METHODS- Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911
Average C.C. per Liter. from Cross-Sections
COMPUTED BY: E.L.H. CHECKED BY:

THE NARROWS

FILE NO 205
ACC. NO 11392.
SHEET 1 TOT. IN COMP. 3
DATE Jan 12. 1912.

MADE IN CONNECTION WITH

Date of Collection Sept 26 1911 LWGov. I 4.17 AM Hw Io.33 AM LW 4.57 PM

	Sample	Time	Oxygen CC per Liter	Averages CC per Liter		
				Each Current		Both Currents All Depths
				Each Depth	All Depths	
Flood Current						
Depth 1 Ft	1474	6.30 AM	3.69			
	1477	6.39 "	3.78			
	1480	6.48 "	3.91			
	1483	6.57 "	3.84			
	1486	7.06 "	3.75			
	1489	8.30 "	4.63			
	1492	8.39 "	4.76			
	1495	8.48 "	4.78			
	1498	8.57 "	4.83			
	1501	9.06 "	4.72			
	1504	10.30 "	4.78			
	1507	10.39 "	4.90			
	1510	10.48 "	4.92			
	1513	10.57 "	5.00	(15 samples)		
	1516	11.06 "	5.00	4.49		
Mid-depth	1475	6.32 "	3.93			
	1478	6.41 "	3.92			
	1481	6.50 "	3.91			
	1484	6.59 "	3.84			
	1487	7.08	3.89			
	1490	8.32 "	4.94			
	1493	8.41 "	5.04			
	1496	8.50 "	4.92			
	1499	8.59 "	5.00			
	1502	9.08 "	5.00			
	1505	10.33 "	4.94			
	1508	10.41 "	5.04			
	1511	10.50 "	4.92			
	1514	10.59 "	5.00	(3 samples)		
	1517	11.08 "	5.00	4.61		
Bottom	1476	6.34 "	3.83			
			Same as Mid-depth	(3 samples)	(6 samples)	
	1518	11.10 "	5.00	4.61	4.57	
				6 x 99	P 62	

SUBJECT: DISPOSAL METHODS- Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911
Average C.C. per Liter. from Cross-Sections
THE NARROWS
COMPUTED BY: ELH. CHECKED BY:
FILE NO 205
ACC. NO 1H393
SHEET 2 TOT. IN COMP 3
DATE Jun 12 1912
MADE IN CONNECTION WITH

Date of Collection, Sept 26 1911 LW Gov I 4[17] AM HW 10[23] AM LW 4[37] PM

	Sample No.	Time	Oxygen C C per Liter	Averages C C per Liter		
				Each Current		Both Currents & All Depths
				Each Depth	All Depths	
Ebb Current						
Depth 1 Ft	1519	12 30 PM	4.78			
	1522	12 39 "	4.90			
	1525	12 48 "	4.78			
	1528	12 57 "	4.85			
	1531	1 06 "	4.72			
	1534	2 30 "	4.38			
	1537	2 39 "	4.48			
	1540	2 48 "	4.34			
	1543	2 57 "	4.26			
	1546	3 06 "	4.31			
	1549	4 36 "	3.96			
	1552	4 39 "	4.06			
	1555	4 48 "	4.06			
	1558	4 57 "	3.98			
	1561	5 06 "	3.89			
	1564	6 00 "	3.69			
	1567	6 08 "	3.78			
	1570	6 16 "	3.91			
	1573	6 24 "	3.84	(20 samples)		
	1576	6 32 "	3.75	4.24		
			2.99	P.63		

Subject: DISPOSAL METHODS- Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911
Average C.C. per Liter. from Cross-Sections
Computed by: C.H.H. Checked by

THE NARROWS

File No 205
Acc No IH 394
Sheet 3 of 10 Sheets 3
Date Jun 12 1912.

Made in connection with

Date of Collection Sept 20 1911 Lw Gov I 4.17 AM HW 10.32 AM

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter		
				Each Current		Both Currents
				Each Depth	All Depths	All Depths
Flood Current see sheet 1					(45 samples) 4.57	
Ebb Current						
Depth 1 Ft. see sheet 2				(24 samples) 4.24		
Mid-depth	1520	12.32 PM	4.78			
	1523	12.41 "	4.96			
	1526	12.50 "	4.92			
	1529	12.59 "	4.93			
	1532	1.08 "	4.87			
	1535	2.33 "	4.51			
	1538	2.41 "	4.48			
	1541	2.50 "	4.34			
	1544	2.58 "	4.26			
	1547	3.08 "	4.31			
	1550	4.3– "	3.96			
	1553	4.41 "	4.06			
	1556	4.50 "	4.–			
	1559	4.59	3.98			
	1562	5.08 "	4.0			
	1565	6.02 "	3.83			
	1568	6.10 "	3.92			
	1571	6.18 "	4.06			
	1574	6.26 "	3.98	(24 samples)		
	1577	6.34 "	3.89	4.30		
Bottom	1521	12.34 "	4.78			
			same as Mid-depth	(24 samples)	(48 samples)	(69 samples)
	1578	6.36 "	3.89	4.30	4.28	4.42
				6.99	6.99	

SUBJECT: DISPOSAL METHODS Dilution
New York Harbor Dissolved Oxygen in 1911 UPPER BAY
Average % of Saturation - f NEAR ROBBINS REEF
COMPUTED BY E.A.H. CHECKED BY
FILE NO 205
ADD NO IH 373
SHEET 1 TOT IN CONN 2
DATE Jan 9 1912

Date of Collection Oct 16, 1911 LW Gov I 8.9 AM HW 3.9 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current: Each Depth	Each Current: All Depths	Both Currents All Depths
Ebb Current						
Depth 1 Ft.	2038	9.20 AM	64 %			
	2041	9.35 "	64			
	2044	9.50 "	65			
	2047	11.20 "	65			
	2050	11.35 "	66	(4 samples)		
	2053	11.50 "	66	65.0 %		
Mid-depth	2039	9.22 "	65			
	2042	9.37 "	68			
	2045	9.52 "	66			
	2048	11.22 "	65			
	2051	11.37 "	66	(4 samples)		
	2054	11.52 "	66	66.0		
Bottom	2040	9.25 "	65			
	⋮	⋮	same as Mid depth	(4 samples)	(12 samples)	
	2055	11.55 "	66	66.0	65.7 %	
Flood Current see sheet 2						
			E. 99	P. 65		

Subject: Disposal Methods Dilution. File No 205
New York Harbor: Dissolved Oxygen in 1911 UPPER BAY Acc. No 11374
Average % of Saturation - from Cross Sections NEAR ROBBINS REEF Sheet 2 Tot. in Comp 2
Computed by EAH. Checked by Date Jan 9 1912
Made in connection with

Date of Collection Oct 16, 1911 Lw Gov I 9^m AM Hw 3^h2 PM

	Sample No.	Time	% of Saturation	Averages Percent of Saturation: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
					(7 samples)	
Ebb Current, see sheet 1					65.7%	
Flood Current						
Depth 1 Ft	2056	1 10 PM	68%			
	2059	1 35 "	66			
	2062	1 50 "	70			
	2065	3 20 "	76			
	2068	3 35 "	75			
	2071	3 50 "	76			
	2074	5 10 "	77			
	2077	5 18 "	75	(9 samples)		
	2080	5 26 "	75	73.1%		
Mid-depth	2057	1 22 "	77			
	2060	1 37 "	73			
	2063	1 52 "	76			
	2066	3 22 "	77			
	2069	3 37 "	76			
	2072	3 52 "	77			
	2075	5 13 "	78			
	2078	5 30 "	79	(8 samples)		
	2081	5 38 "	77	76.7		
Bottom	2058	1 35 "	77			
			Same as			
			Mid depth	(8 samples)	(23 samples)	(45 samples)
	2082	5 30 "	77	76.7	75.5	71.7

See (205 / 11255) for sketch showing locations where samples were taken
F. 99 P. 66

Subject: DISPOSAL METHODS- Dilution
New York Harbor Dissolved Oxygen in 1911 — UPPER BAY — File No 205
Average C.C. per Liter. — NEAR ROBBINS REEF — Acc. No 11411
Computed by Ed H. — Checked by — Sheet 1 — Vol. in Comp 2.
Date Jan 15 1912.

Date of Collection, Oct. 16 1911 LW Gov I 9^05 AM HW 3^09 PM.

	Sample No	Time	Oxygen C C per Liter	Averages C C per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents & All Depths
Ebb Current						
Depth 1 Ft	2038	9 20 AM	3 96			
	2041	9 35 "	3 98			
	2044	9 50 "	4 03			
	2047	11 20 "	4 10			
	2050	11 35 "	4 12	(6 samples)		
	2053	11 50 "	4 17	4 06		
Mid-depth	2039	9 22 "	3 96			
	2042	9 37 "	4 12			
	2045	9 52 "	4 03			
	2048	11 22 "	3 96			
	2051	11 37 "	3 98	(6 samples)		
	2054	11 52 "	4 03	4 01		
Bottom	2040	9 25	3 96			
	(	(	Same as Mid-depth	(6 samples)	(12 samples)	
	2055	11 55 "	4 03	4 01	4 03	
Flood Current, see sheet 2.			6. 99	7 47		

Subject: Disposal Methods - Dilution — File No. 205
New York Harbor Dissolved Oxygen in 1911 — UPPER BAY — Acc. No. 111412
Average C.C. per Liter. — Near Robbin Reef — Buoy 2 Tow or Cruise 2
Computed by: C.H.M. — Checked by — Date June 15 1912.
Work in connection with

Date of Collection, Oct. 16. 1911 — L.W. Gov. I. 9^m AM H.W. 3^h 39^m PM

	Sample No.	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Ebb Current see sheet 1					(10 samples) 4.04	
Flood Current						
Depth 1 Ft	2056	1.30 PM	4.24			
	2059	1.35 "	4.14			
	2062	1.50 "	4.31			
	2065	3.20 "	4.65			
	2068	3.35 "	4.55			
	2071	3.50 "	4.58			
	2074	5.10 "	4.65			
	2077	5.18 "	4.55	(9 samples)		
	2080	5.26 "	4.53	4.47		
Mid-depth	2057	1.32 "	4.65			
	2060	1.37 "	4.40			
	2063	1.52 "	4.58			
	2066	3.22 "	4.65			
	2069	3.37 "	4.55			
	2072	3.52 "	4.58			
	2075	5.12 "	4.65			
	2078	5.20 "	4.68	(9 samples)		
	2081	5.28 "	4.58	4.59		
Bottom	2058	1.25	4.65			
			Same as Mid-depth	(9 samples)	(19 samples)	(28 samples)
	2082	5.30	4.58	4.59	4.55	4.29
				6.99	1.68	

SUBJECT: DISPOSAL METHODS Dilution
New York Harbor Dissolved Oxygen in 1911 — UPPER BAY — NEAR ROBBINS REEF
Average % of Saturation.
COMPUTED BY: Clift. CHECKED BY:
FILE NO 205 ACC NO 1M375 SHEET NO. OF COURT
DATE Jan 9 1912.

Date of Collection Oct 23 1911 HW Govt 8³⁷ AM LW 3¹⁵ PM.

	Sample No.	Time	% of Saturation	Averages Percent of Saturation Each Current: Each Depth	Each Current: All Depths	Both Currents: All Depths
Flood Current						
Depth 1 Ft	2083	9.30 AM	78 %			
	2086	9 49 "	74 "			
	2089	10 00 "	77 "	(4 samples)		
	2092	10 15 "	78 "	76.0 %		
Mid-depth	2084	9 32 "	75			
	2087	9 47 "	76			
	2090	10 02 "	78	(4 samples)		
	2093	10 17 "	80	77.2		
Bottom	2085	9 35 "	75			
	2088	9 50 "	77			
	2091	10 05 "	79	(4 samples)	(8 samples)	
	2094	10 20 "	80	77.0	77.0 %	
Ebb Current						
Depth 1 Ft	2098	12 30 PM	64			
	2101	1245 "	67			
	2104	100 "	73			
	2107	115 "	74			
	2113	330 "	69			
	2116	345 "	69			
	2119	4 00 "	67	(8 samples)		
	2122	4 15 "	66	68.6		
Mid-depth	2099	12 32 "	66			
	2102	12 47 "	74			
	2105	102 "	73			
	2108	117 "	77			
	2114	332 "	69			
	2117	347 "	69			
	2120	4 02 "	67	(8 samples)		
	2123	4 17 "	68	70.2		
Bottom	2100	12 35 "	66			
	⋮	⋮	same as Mid-depth			
	2124	4 20 "	68	(8 samples) 70.2 Ex 99	(8 samples) 69.7 P 69	(16 samples) 73%

Subject: Disposal Methods - Dilution — File No. 20.6
New York Harbor - Dissolved Oxygen in Mil. UPPER BAY — Acc. No. 11413
Average C.C. per Liter. NEAR ROBBINS REEF — Sheet No. or Chart
Computed by C.A.A. Checked by — Date Jan. 16 1912

Date of Collection, Oct. 23, 1911 HWGw. I. 8.47 AM LW 3.18 PM

	Sample No	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents, All Depths
Flood Current						
Depth 1 Ft.	2083	9.30AM	4.78			
	2086	9.45 "	4.72			
	2089	10.00 "	4.85	(4 samples)		
	2092	10.18 "	4.92	4.81		
Mid-depth	2084	9.35 "	4.63			
	2087	9.47 "	4.72			
	2090	10.02 "	4.83	(4 samples)		
	2093	10.17 "	4.91	4.78		
Bottom	2085	9.38 "	4.65			
	2088	9.50 "	4.72			
	2091	10.05 "	4.83	(6 samples)	(12 samples)	
	2094	10.20 "	4.92	4.76	4.79	
Ebb Current						
Depth 1 Ft.	2098	12.30PM	4.10			
	2101	12.45 "	4.31			
	2104	1.00 "	4.48			
	2107	1.18 "	4.73			
	2113	3.30 "	4.81			
	2116	3.45 "	4.55			
	2119	4.00 "	4.40	(8 samples)		
	2122	4.18 "	4.4	4.46		
Mid-depth	2099	12.33 "	4.10			
	2102	12.47 "	4.58			
	2105	1.01 "	4.55			
	2108	1.17 "	4.76			
	2114	3.33 "	4.58			
	2117	3.47 "	4.14			
	2120	4.02 "	4.24	(8 samples)		
	2123	4.17 "	4.34	4.43		
Bottom	2100	12.36 "	4.10			
			Same as Mid-depth	(8 samples)	(16 samples)	(36 samples)
	2124	4.20 "	4.34	4.43	4.44	4.62

Co 19 P 70

Subject: DISPOSAL METHOD Dilution
NEW YORK HARBOR Dissolved Oxygen in 1911 UPPER BAY
Averages of Saturation NEAR ROBBINS REEF
Computed by Bell Checked by
File No 20.5
Acc. No 11357G
Order
Tab. in Case
Date Jan 10

Date of Collection Oct 24 1911 HW Gov I 9° AM LW 3:11 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current						
Depth 1 Ft.	2135	9:16 AM	72%			
	2131	10.00 -	73			
	2134	10.15 -	76	(4 samples)		
	2137	10.40 -	74	74.2%		
Mid depth	2129	9.48 -	69			
	2132	10.03 -	70			
	2133	10.18 -	72	(4 samples)		
	2138	10.33 -	75	72.5		
Bottom	2130	9.51 -	69			
	2135	10.05 -	70			
	2136	10.21 -	72	(4 samples)	(8 samples)	
	2139	10.36 -	79	72.5	73.1%	
Ebb Current						
Depth 1 Ft.	2145	12.45 PM	77			
	2146	1.00 -	78			
	2149	1.15 -	79			
	2152	1.30 -	84			
	2158	5.45 -	76			
	2161	4.00 -	78			
	2164	4.15 -	79	(8 samples)		
	2167	4.30 -	80	78.5		
Mid depth	2144	12.48 -	79			
	2147	1.00 -	80			
	2150	1.12 -	81			
	2154	1.43 -	83			
	2159	5.47 -	78			
	2162	4.02 -	79			
	2165	4.17 -	81	(8 samples)		
	2168	4.32 -	83	80.5		
Bottom	2145	12.51 -	79			
			Same as Mid-depth	(8 samples)	(24 samples)	(56 samples)
	2169	4.35 -	83	80.5	79.8	76%
				G 49	P 71	

Subject: Biological Methods - Dilution
New York Harbor Polluted Currents 10/11 Upper Bay
Average C.C. per Liter
Hour Readings Kept
Plate No. 20.5
Book No. 1H.4.16
Sheet
Date Jan. 16

Date of Collection. Oct. 9th 1911 H.W. Gov I 9th 08M L.W. 3th P.M.

	Sample No.	Time	Organic C.C. per Liter	Average C.C. per Liter		
				Flood Current		Both Currents All Depths
				Each Depth	All Depths	
Flood Current						
Depth 1M.	3/58	9.05 A.M.	0.65			
	3/61	10 "	0.72			
	3/36	10.01 "	0.93	(2 Samples)		
	3/37	10.02 "	0.98	0.79		
Mid-depth	3/34	9.03 "	0.89			
	3/32	10.04 "	0.99			
	3/35	10.03 "	0.85	(2 Samples)		
	3/38	10.04 "	0.93	0.87		
Bottom	3/33	9.01 "	0.89			
	3/30	10.06 "	0.98			
	3/36	10.01 "	0.92	(2 Samples)	(3 Samples)	
	3/39	10.04 "	0.98	0.93	0.86	
Ebb Current						
Depth 1M.	3/40	10.40 AM	0.99			
	3/46	1.00 "	0.98			
	3/49	1.05 "	0.91			
	3/56	1.30 "	0.96			
	3/53	9.05 "	0.84			
	3/61	9.00 "	0.91			
	3/60	9.05 "	0.95	(2 Samples)		
	3/47	9.30 "	0.88	0.90		
Mid-depth	3/48	10.39 "	0.94			
	3/43	1.03 "	0.99			
	3/52	1.10 "	0.91			
	3/55	1.33 "	0.94			
	3/59	9.07 "	0.96			
	3/62	9.02 "	0.90			
	3/45	9.17 "	0.96	(2 Samples)		
	3/44	9.32 "	0.96	0.96		
Bottom	3/45	12.51	0.95 Same as Mid depth	(2 samples)	(2 Samples)	(2 Samples)
	3/42	9.35 "	0.96	0.96	0.96	0.93
					0.97	0.90

Subject: Disposal Methods - Dilution
New York Harbor Sewage Disposal Problem 1911 Lower End of Raritan Bay
Average % of Saturation from Upper East to Keyport Bay
Collected by: Ellis

File No 20.5
Case No 11964
Sheet 1 to Sheets 9
Date Jan 9 1912

Date of Collection Oct. 6 1911. HW Boat 6th AM 6h 15m PM Ht 2.1 Ft

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current Depth 1 Ft	1868	8 am Bay	60%			
	1870	8:45 "	61			
	1872	9:30 PM	61			
	1874	9:55 "	60			
	1877	10:20 "	61			
	1879	9:25 "	60			
	1881	9:56 "	61			
	1883	10:00 "	62			
	1886	10:00 "	59			
	1888	9:16 "	59			
	1890	8:20 "	57	(4 Samples)		
	1892	8:06 "	58	60.0%		
Mid depth and Bottom	1869	8:05 AM	59			
	1871	8:48 "	57			
	1873	8:19 "	60			
	1875	9:32 PM	61			
	1876	9:58 "	60			
	1878	10:00 "	65			
	1880	9:45 "	61			
	1882	8:45 "	60			
	1885	9:58 "	61			
	1887	10:00 "	62			
	1889	9:08 "	61			
	1891	8:10 "	59			
	1893	8:16 "	58			
	1894	8:00 "	59	(4 Samples)	(8 Samples)	
	1895	8:08 "	58	59.1	60.6%	
Ebb Current. (See Sheet 9)				61.99	59.10	

Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911 Lower End of
Average % of Saturation from Cross Sections Newark Bay

Plate No 205
Acc. No IN 365
Sheet 2 3
Date Jan 8

Computed by GEA Checked by

Date of Collection Oct 6 1911 HW Curr 1 0 PM LW 10 PM HW 6 12 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation		
				Ebb Current		Both Currents in All Depths
				Each Depth	All Depths	
Ebb Current Depth 1 ft	1835	8:40 AM	62 %			
	1836	8:20 -	61			
	1837	8:16 -	62			
	1838	10:00 -	71			
	1841	10:00 -	68			
	1844	10:14 -	66			
	1846	10:30 -	65			
	1848	10:16 -	64			
	1850	12:00 M	66			
	1851	12:00 M	68			
	1900	12:12 -	70			
	1857	12:18 -	71			
	1859	12:24 -	71			
	1861	2:00 -	70			
	1865	2:04 -	69			
	1866	2:12 -	69			
	1868	2:16 -	64	Average		
	1870	2:20 -	66	66.4 %		
Mid depth and Bottom	See Sheet 3				6.99	7.14

Disposal Methods Division — File No. 20.5
New York Harbor Dissolved Oxygen in PPM — Lower Bay or — Acc. No. IH366
Area % of Saturation from Cross Sections NEWARK BAY — Sheet 3 — 3
Computed by Card — Checked by — Date Jan 8 — 61

Date of Collection Oct 6 1961 HW Sandy Hook 6:37 AM LW 12:41 PM HW 6:55 PM

	Sample No	Time	% of Saturation	Averages Percent of Saturation Each Current Each Depth	Each Current All Depths	Both Currents All Depths
Flood Current (see sheet)					(27 samples) 60.6%	
Ebb Current Depth 1.5' (see sheet 2)				(18 samples) 66.4%		
Mid depth and Bottom	1934	8:11 AM	63%			
	1936	8:22 "	61			
	1938	8:39 "	65			
	1940	10:05 "	71			
	1942	10:09 "	71			
	1945	10:20 "	68			
	1946	10:26 "	67			
	1947	10:33 "	66			
	1948	10:38 "	64			
	1951	(10:45 PM)	69			
	1953	12:06 "	68			
	1954	12:09 "	60			
	1956	12:14 "	73			
	1958	12:20 "	69			
	1960	12:26 "	71			
	1962	2:03 "	70			
	1964	2:09 "	67			
	1965	2:08 "	67			
	1967	2:14 "	69			
	1969	2:20 "	64	(9 samples)	(18 samples)	(36 samples)
	1971	2:26 "	66	67.2	66.8	64.1%
					0.99	r = .77

Subject: Chemical Method - Dilution
New York Harbor Dissolved Oxygen in 1911 Lower End of
Average C.C. per Liter - from Cross-Section Newark Bay
Computed by BJA Checked by

File No. 20.5
Acc. No. IH 402
Sheet 1 Tot. in Comp. 3
Date Jan. 13. 1912.

Made in connection with

Date of Collection Oct. 6. 1911 HW Gov. I 6^{30} PM LW 12^{54} PM HW 6.35 PM.

	Sample No.	Time	Oxygen C.C. per Liter	Averages C.C. Per Liter: Each Current, Each Depth	Each Current, All Depths	Both Currents All Depths
Flood Current						
Depth 1 Ft.	1828	8.00 AM	3.88			
	1830	8.06 "	3.84			
	1832	3.30 PM	3.88			
	1834	3.36 "	3.84			
	1877	3.42 "	3.89			
	1879	3.48 "	3.88			
	1881	3.56 "	3.92			
	1883	5.00 "	3.88			
	1885	5.06 "	3.72			
	1888	5.14 "	3.61			
	1890	5.20 "	3.55	(13 Samples)		
	1892	5.26 "	3.68	3.79		
Mid-depth and Bottom	1829	8.02 AM	3.88			
	1831	8.08 "	4.12			
	1833	8.18 "	3.70			
	1873	3.32 PM	3.86			
	1875	3.36 "	3.84			
	1876	3.40 "	4.12			
	1878	3.46 "	3.89			
	1880	3.52 "	3.83			
	1882	3.58 "	3.92			
	1884	5.02 "	3.88			
	1886	5.08 "	3.84			
	1887	5.10 "	3.98			
	1889	5.16 "	3.61			
	1891	5.22 "	3.55	(15 Samples)	(27 Samples)	
	1893	5.28 "	3.64	3.85	3.82	
				L 94	P 76	

SUBJECT DISPOSAL METHODS - DILUTION — FILE NO 21.5
NEW YORK HARBOR DISSOLVED OXYGEN IN 1911 LOWER END OF — ACC NO IH 409
AVERAGE C.C. PER LITER FROM CROSS-SECTIONS NEWARK BAY — SHEET 2 TOT IN CONN 3
COMPUTED BY C.A.N CHECKED BY — DATE JAN. 13 19 12
MADE IN CONNECTION WITH

DATE OF COLLECTION, OCT. 6. 1911. HW GOV. I 6^m A.M. LW 12^h 45^m P.M. HW 6^h 51^m P.M.

	Sample No.	Time	Oxygen C.C. per Liter	Averages C.C. per Liter: Each Current Each Depth	Each Current All Depths	Both Currents & All Depths.
EBB CURRENT						
DEPTH 1 FT.	1833	8.14 AM	3.69			
	1835	8.30 "	3.89			
	1837	8.36 "	3.92			
	1839	10.00 "	4.48			
	1841	10.06 "	4.36			
	1844	10.19 "	4.17			
	1846	10.30 "	4.10			
	1848	10.36 "	4.06			
	1850	12.40 PM	4.18			
	1852	12.46 PM	4.36			
	1855	12.58 "	4.44			
	1857	12.18 "	4.51			
	1859	12.34 "	4.48			
	1861	2.00 "	4.48			
	1863	2.04 "	4.36			
	1866	2.13 "	4.17			
	1868	2.18 "	4.10			
	1870	2.26 "	4.30	(18 Samples) 4.31		
MID-DEPTH & BOTTOM	SEE SHEET 3			Ex 74	N 77	

SUBJECT: Disposal Methods Dilution
New York Harbor Dissolved Oxygen in 1911 Lower End of
Average C.C. per Liter - from Cross section Newark Bay
COMPUTED BY Colt. CHECKED BY
FILE NO 20 S
ACC NO 1H404
SHEET 3 TOT IN COMP 3
DATE Jan. 15 1912

Date of Collection, Oct. 6, 1911 H.W. Gov I 6.39 AM. L.W. 12.43 P.M. H.W. 6.35 P.M.

	Sample No.	Time	Oxygen C.C. per Liter	Averages C.C. per Liter Each Current Each Depth	Each Current All Depths	Both Currents — All Depths
Flood Current. see sheet 1.					(27 samples) 3.82	
Ebb Current Depth 1 Ft. see sheet 2.				(8 samples) 4.21		
Mid-depth and Bottom	1834	8.16 AM.	3.83			
	1836	8.22 "	3.89			
	1838	8.28 "	3.97			
	1840	10.02 "	4.40			
	1842	10.08 "	4.40			
	1843	10.10 "	4.26			
	1845	10.16 "	4.17			
	1847	10.22 "	4.10			
	1849	10.28 "	4.06			
	1851	12.02 PM	4.32			
	1852	12.08 "	4.26			
	1854	12.08 "	4.16			
	1856	12.14 "	4.38			
	1858	12.20 "	4.38			
	1860	12.26 "	4.48			
	1862	2.02 "	4.26			
	1864	2.08 "	4.26			
	1865	2.08 "	4.26			
	1867	2.14 "	4.17			
	1869	2.20 "	4.20	(31 samples)	(59 samples)	(66 samples)
	1871	2.26 "	4.20	4.23	4.22	4.02
					Fo 59	P 78

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

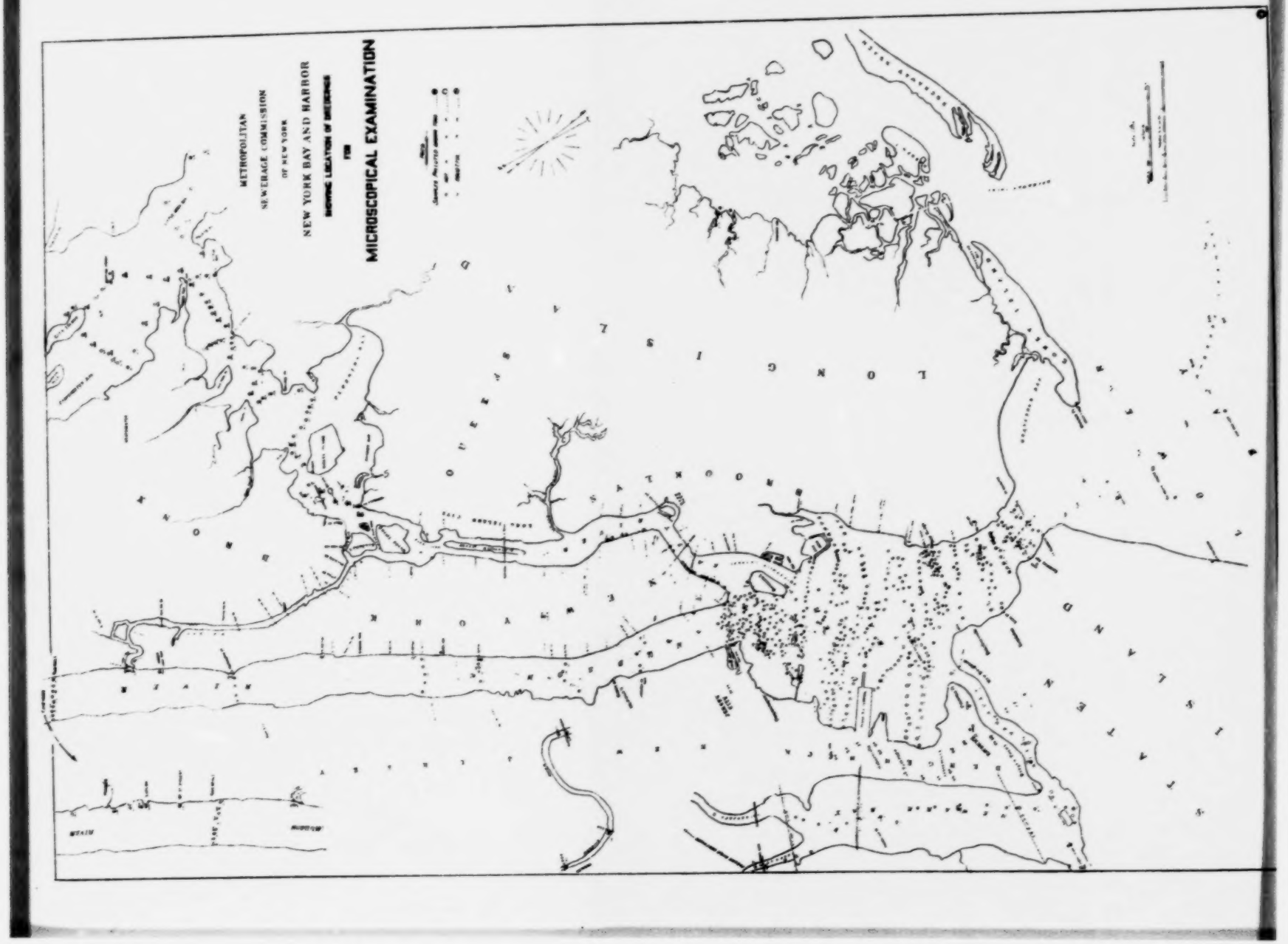
vs.

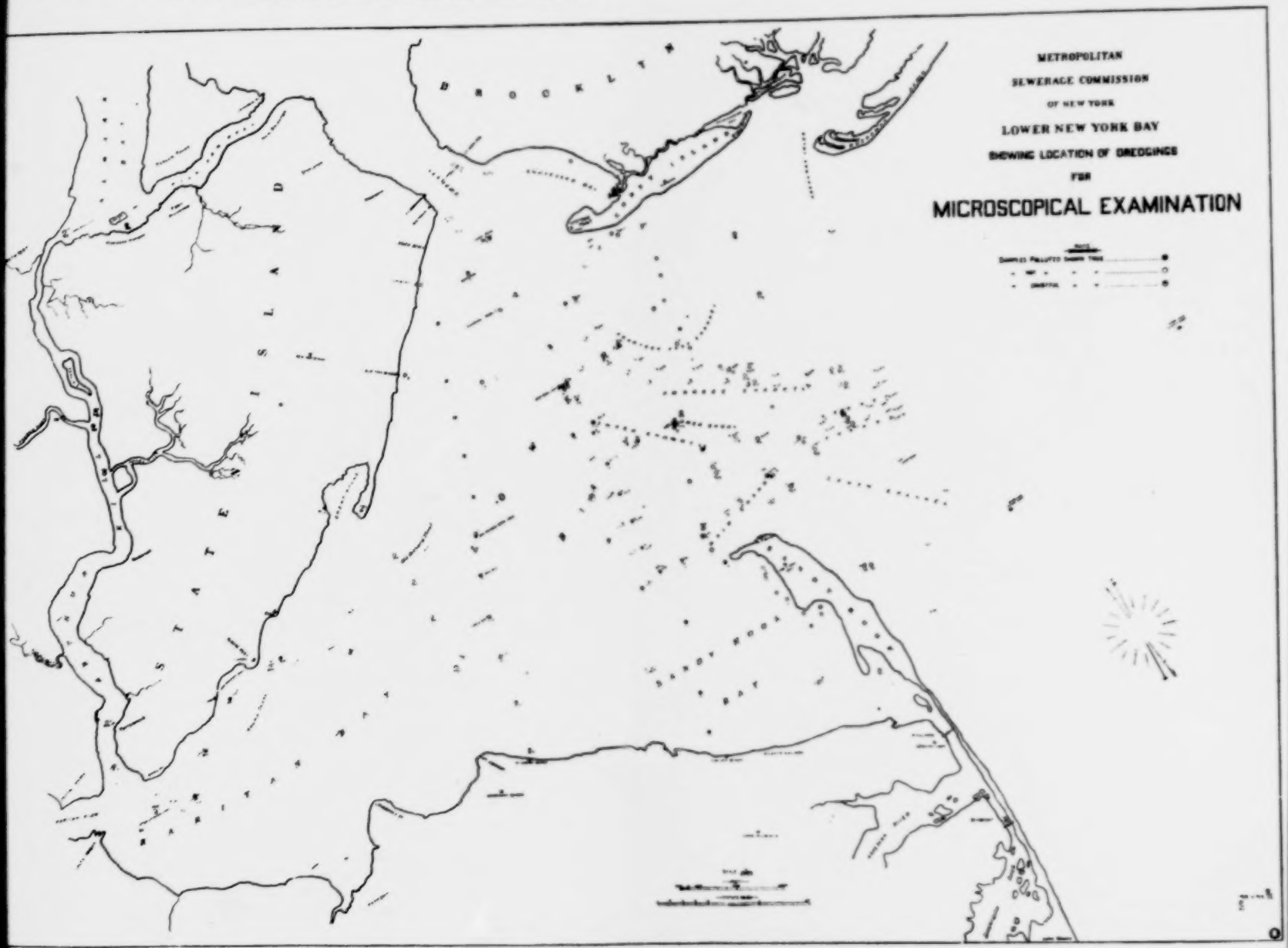
STATE OF NEW JERSEY ET AL.

HERE FOLLOW COMPLAINANTS' EXHIBITS

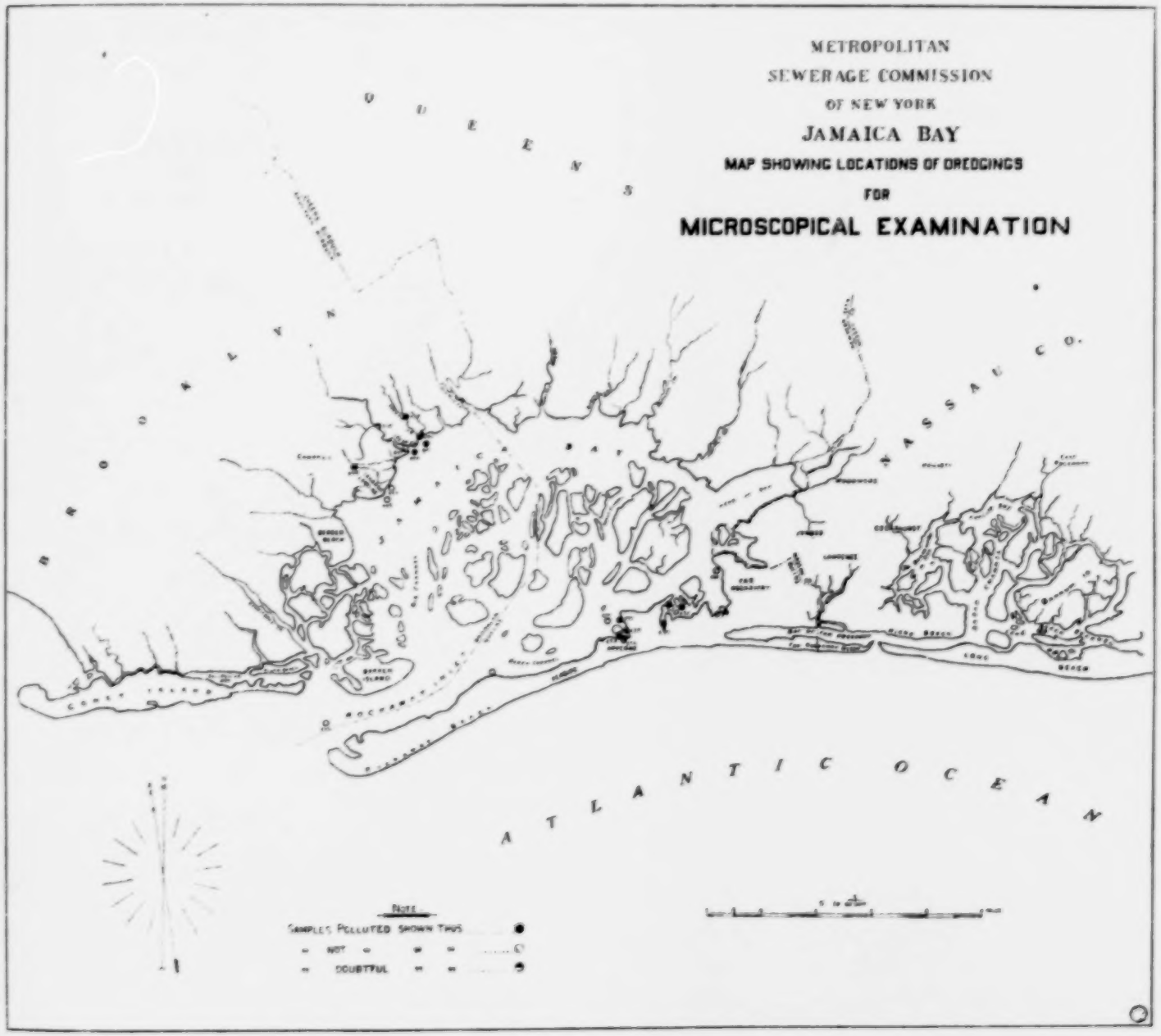
Nos. 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124.

JAMES D. MAHER,
Commissioner.


METROPOLITAN
SEWERAGE COMMISSION
OF NEW YORK
NEW YORK BAY AND HARBOR
SHOWING LOCATION OF MICROSCOPICAL EXAMINATION
LONG ISLAND
STATEN ISLAND
NEW JERSEY



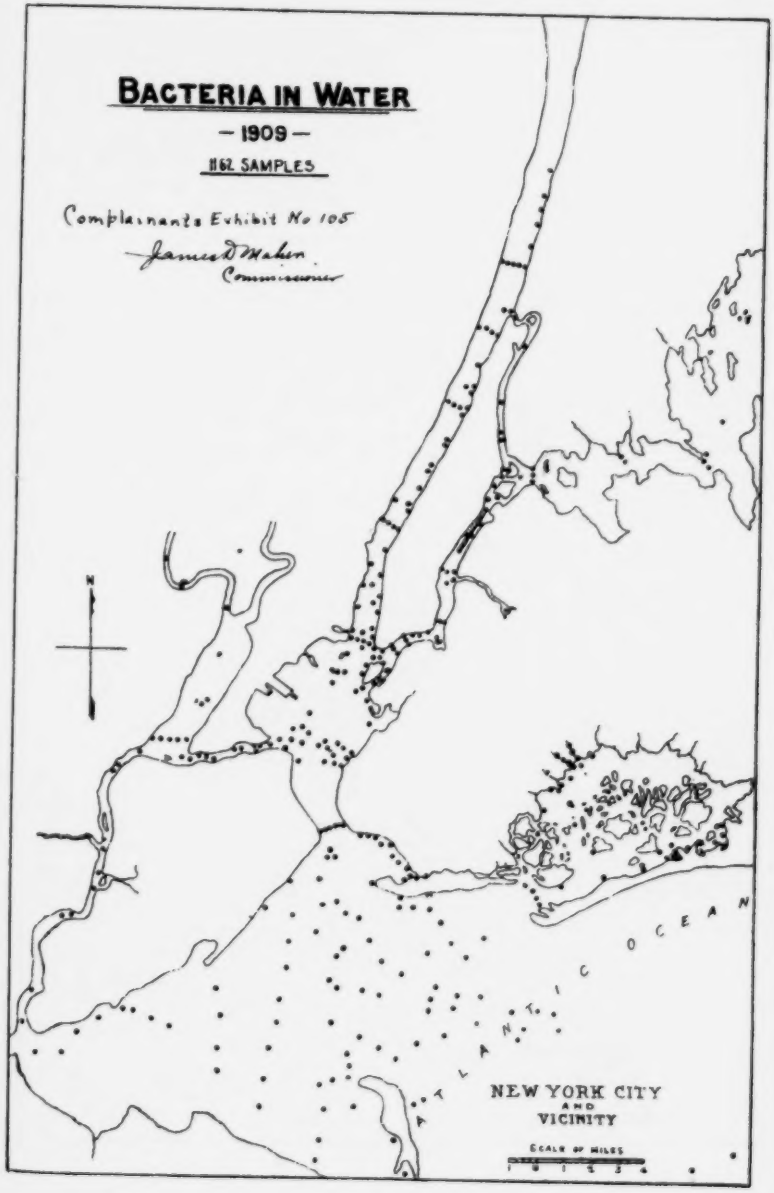
Complainants Exhibit No. 101
James D. Maher.

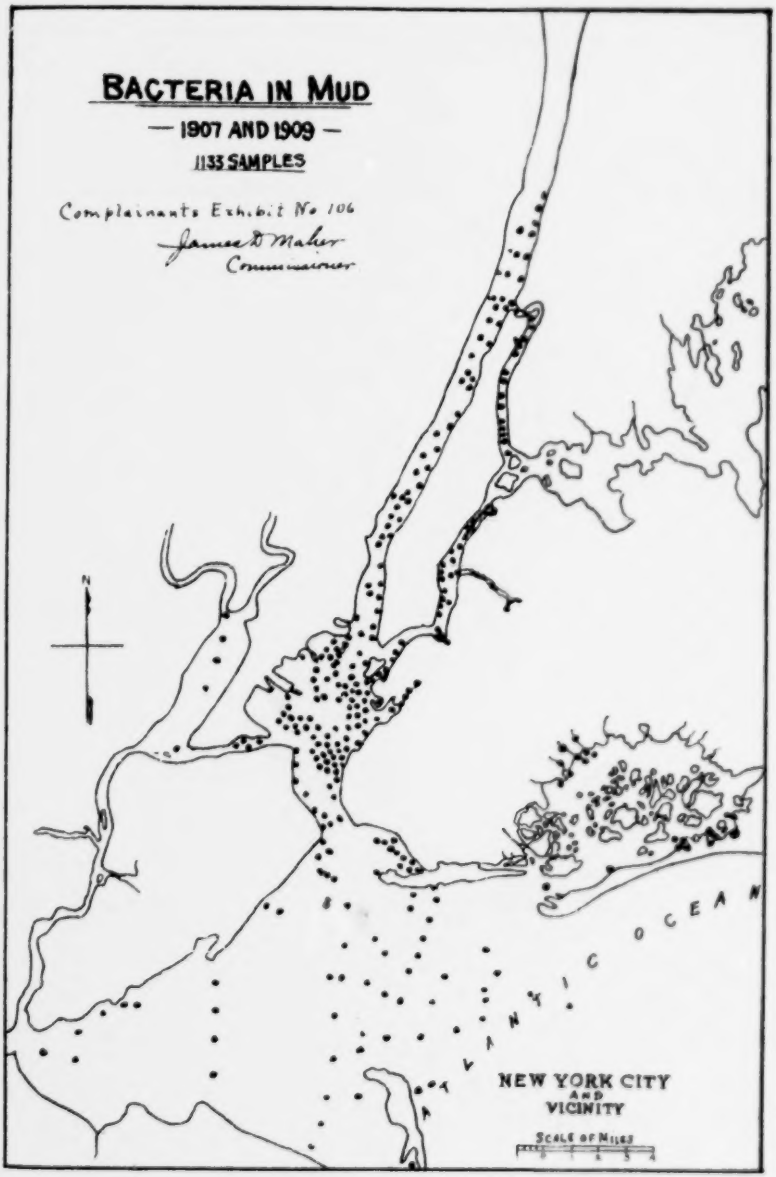


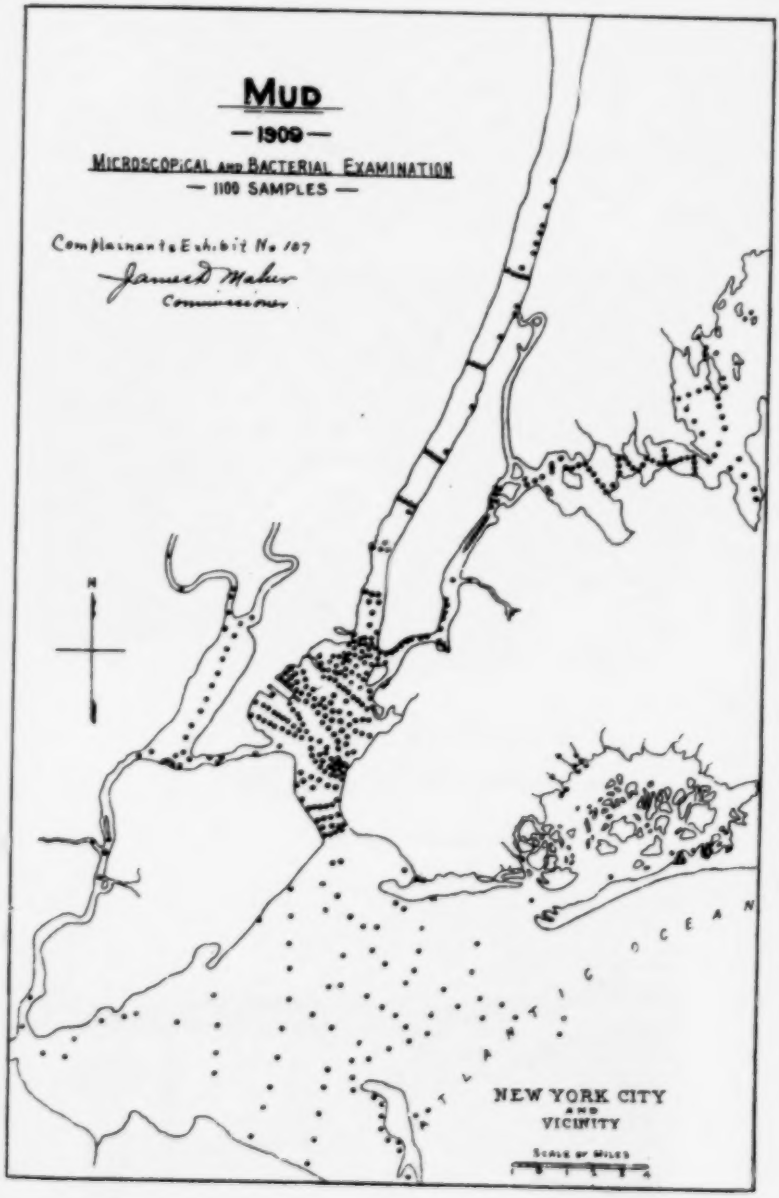
Complainant's Exhibit No. 102
James D. Market

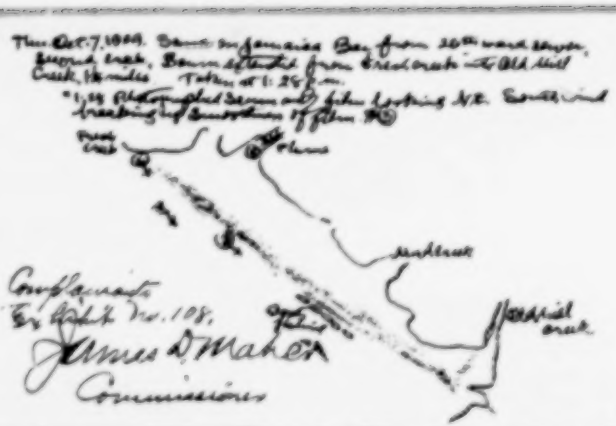

OXYGEN
1911
— 1835 SAMPLES —
Complainants Exhibit No 103
James E Malon
NEW YORK CITY
AND
VICINITY


OXYGEN
1909
— 836 SAMPLES —
Complainant's Exhibit No 104
NEW YORK CITY
AND
VICINITY
ATLANTIC OCEAN


BACTERIA IN WATER
— 1909 —
1162 SAMPLES
Complainant's Exhibit No 105
James D Maben
Commissioner
N
ATLANTIC OCEAN
NEW YORK CITY
AND
VICINITY
SCALE OF MILES
0 1 2 3 4


BACTERIA IN MUD
— 1907 AND 1909 —
1135 SAMPLES
Complainants Exhibit No 106
James B Maher
Commissioner
N
ATLANTIC OCEAN
NEW YORK CITY
AND
VICINITY
SCALE OF MILES


MUD
— 1909 —
MICROSCOPICAL AND BACTERIAL EXAMINATION
— 1100 SAMPLES —
Complainant's Exhibit No. 107
James D. Maher
Commissioner
N
ATLANTIC OCEAN
NEW YORK CITY
AND
VICINITY
SCALE OF MILES





Complainants Exhibit No. 108 D. D. Maher Comm.

Complainants. Ex. Libit No. 109.
James D. Maher
Commissioner



Complainants Ex. No

Complainants Exhibit No. 110
James D. Maher
Commissioner



Complainants Exhibit No. 111
James D. Maher
Commissioner



Ferry
Brooklyn Bridge
Pier



Complainants Exhibit No 115.
James Dreaker
Commissioner.

Complainants Exhibit No. 116
James D. Maher,
Commissioner.



Complainants Exhibit No. 117
James D. Maher,
Commissioner.



Complainants Exhibit No. 118
James D. Maher
Commissioner



Complainants Exhibit No. 119
James D. Maher,
Commissioner.



Complainants Exhibit No. 120
James D. Maher
Commissioner



Complainants Exhibit No. 121,
James D. Maher
Commissioner.



Complainants Exhibit No. 122.
James D. Maher
Commissioner.



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 123.

Showing the Plan of the Harbor and Land Commission of 1895.

JAMES D. MAHER,
Commissioner.



Apparatus for the determination of dissolved oxygen in water by the Levy Method.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 127.

JAMES D. MAHER,
Commissioner.

Complainants Exhibit 127
James D. Maher
Commissioner

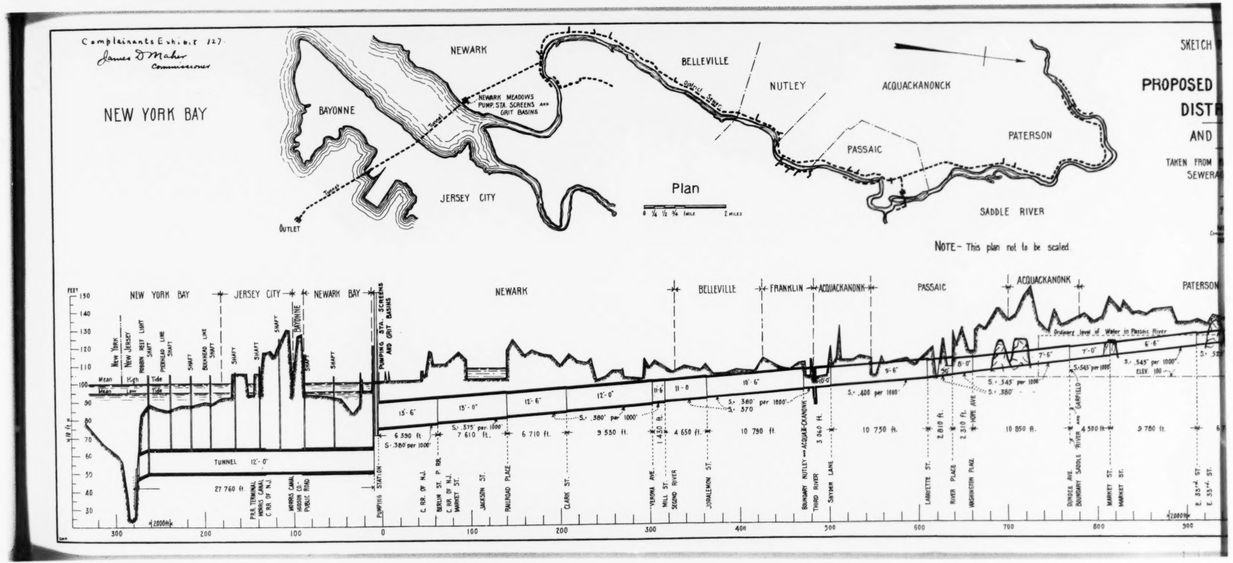
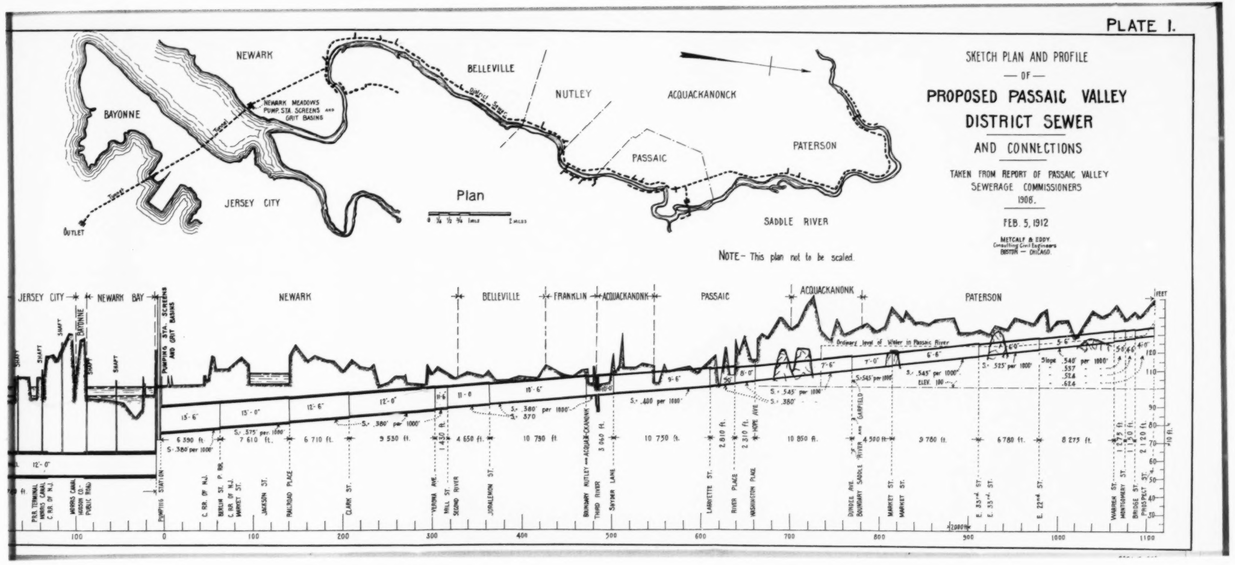


PLATE I.



SKETCH PLAN AND PROFILE
— OF —
PROPOSED PASSAIC VALLEY DISTRICT SEWER AND CONNECTIONS

TAKEN FROM REPORT OF PASSAIC VALLEY SEWERAGE COMMISSIONERS
1908.

FEB. 5, 1912

METCALF & EDDY
Consulting Civil Engineers
BOSTON — CHICAGO

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBITS Nos. 128, 129, 130, 131, 132, 133, and 134.

JAMES D. MAHER,
Commissioner.

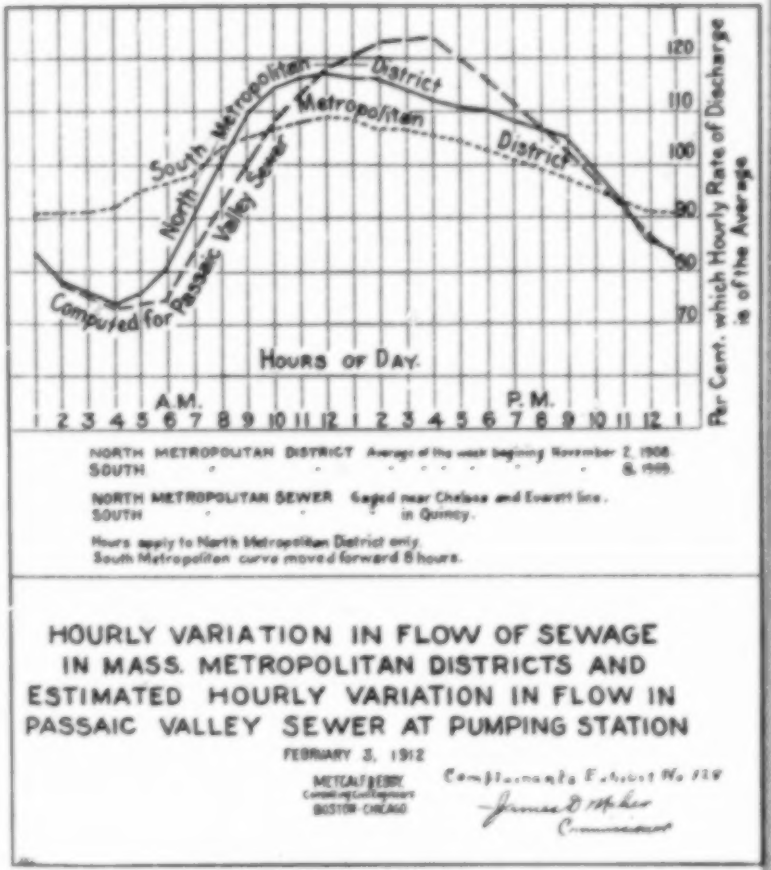
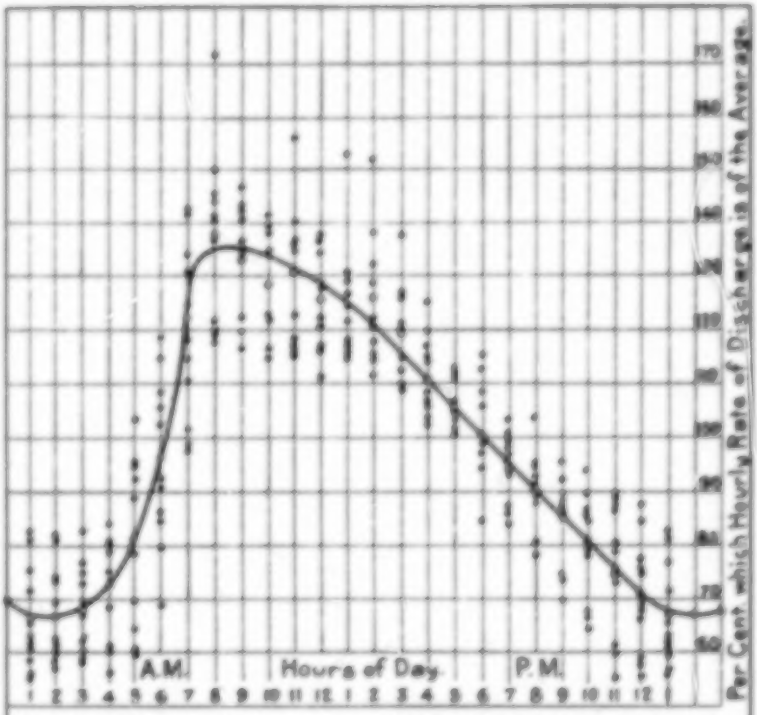

South Metropolitan District
North Metropolitan District
Passaic Valley Sewer
Computed for
HOURS OF DAY.
A.M.
P.M.
1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12 1
120
110
100
90
80
70
Per Cent. which Hourly Rate of Discharge is of the Average
NORTH METROPOLITAN DISTRICT Average of the week beginning November 2, 1908.
SOUTH " " " " " " " 8, 1908.
NORTH METROPOLITAN SEWER Gaged near Chelsea and Everett line.
SOUTH " " " in Quincy.
Hours apply to North Metropolitan District only.
South Metropolitan curve moved forward 8 hours.
HOURLY VARIATION IN FLOW OF SEWAGE IN MASS. METROPOLITAN DISTRICTS AND ESTIMATED HOURLY VARIATION IN FLOW IN PASSAIC VALLEY SEWER AT PUMPING STATION
FEBRUARY 3, 1912
METCALF & EDDY
Consulting Civil Engineers
BOSTON CHICAGO
Complainants Exhibit No 128
James D. Hatcher
Commissioner

Fig. 1.



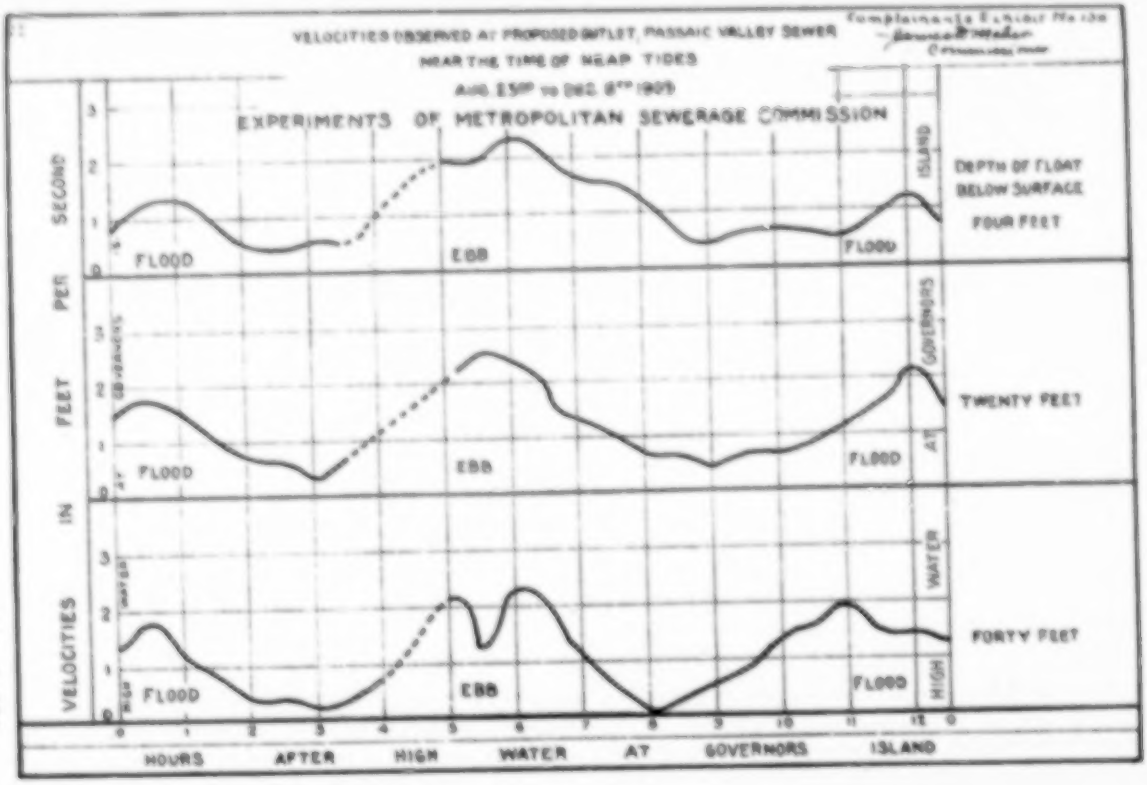
HOURLY VARIATION IN FLOW OF SEWAGE IN VARIOUS CITIES

FEBRUARY 2, 1912.

METCALF & EDDY
Consulting Sanitary Engineers
BOSTON CHICAGO

Complainant's Exhibit Hearing
Commissioner

Fig. 2.


VELOCITIES OBSERVED AT PROPOSED OUTLET, PASSAIC VALLEY SEWER
NEAR THE TIME OF NEAP TIDES
AUG. 25TH TO DEC. 8TH 1909
EXPERIMENTS OF METROPOLITAN SEWERAGE COMMISSION
VELOCITIES IN FEET PER SECOND
DEPTH OF FLOAT BELOW SURFACE
FOUR FEET
TWENTY FEET
FORTY FEET
FLOOD
EBB
FLOOD
ISLAND
GOVERNORS
WATER
HIGH
HOURS AFTER HIGH WATER AT GOVERNORS ISLAND

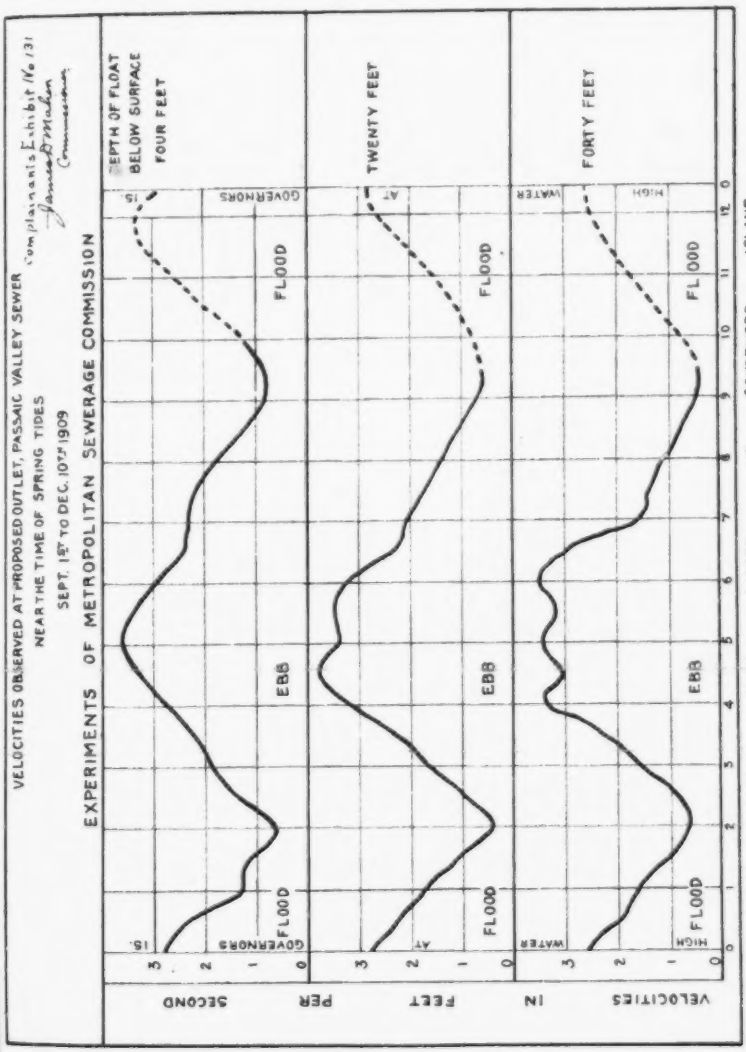


Fig. 4.

2119-Z-324

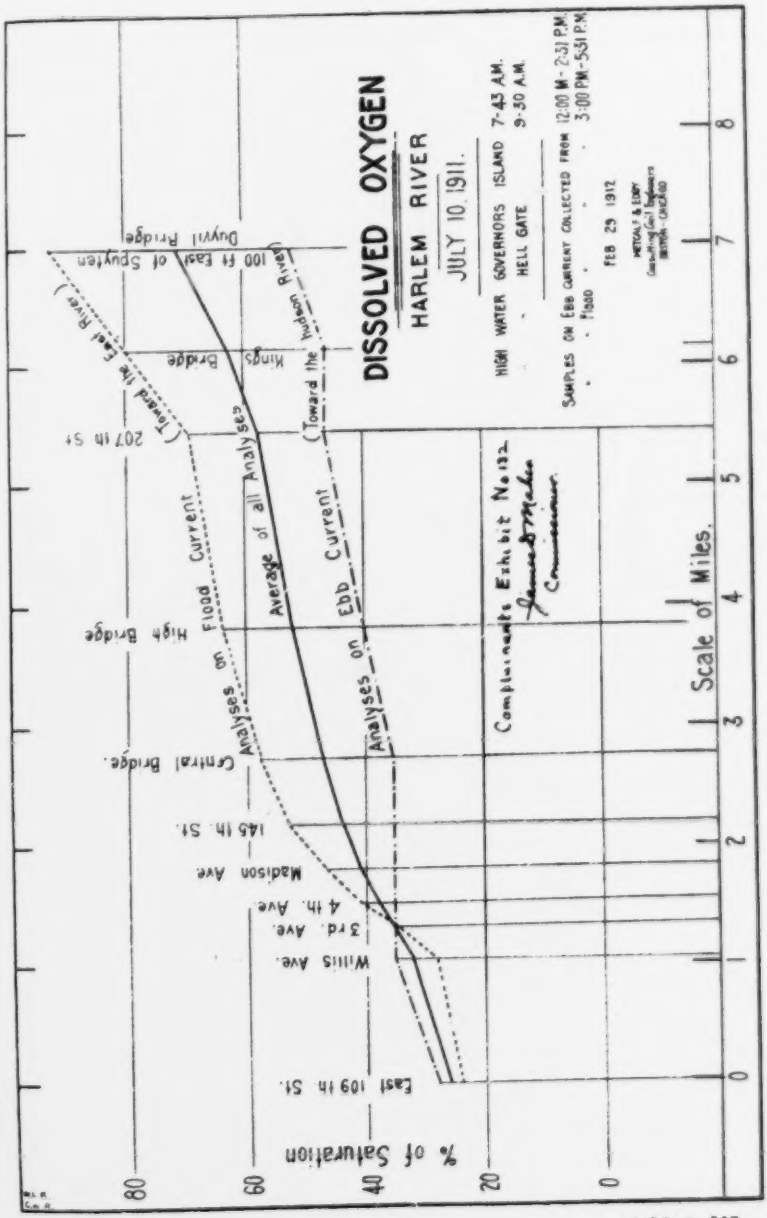
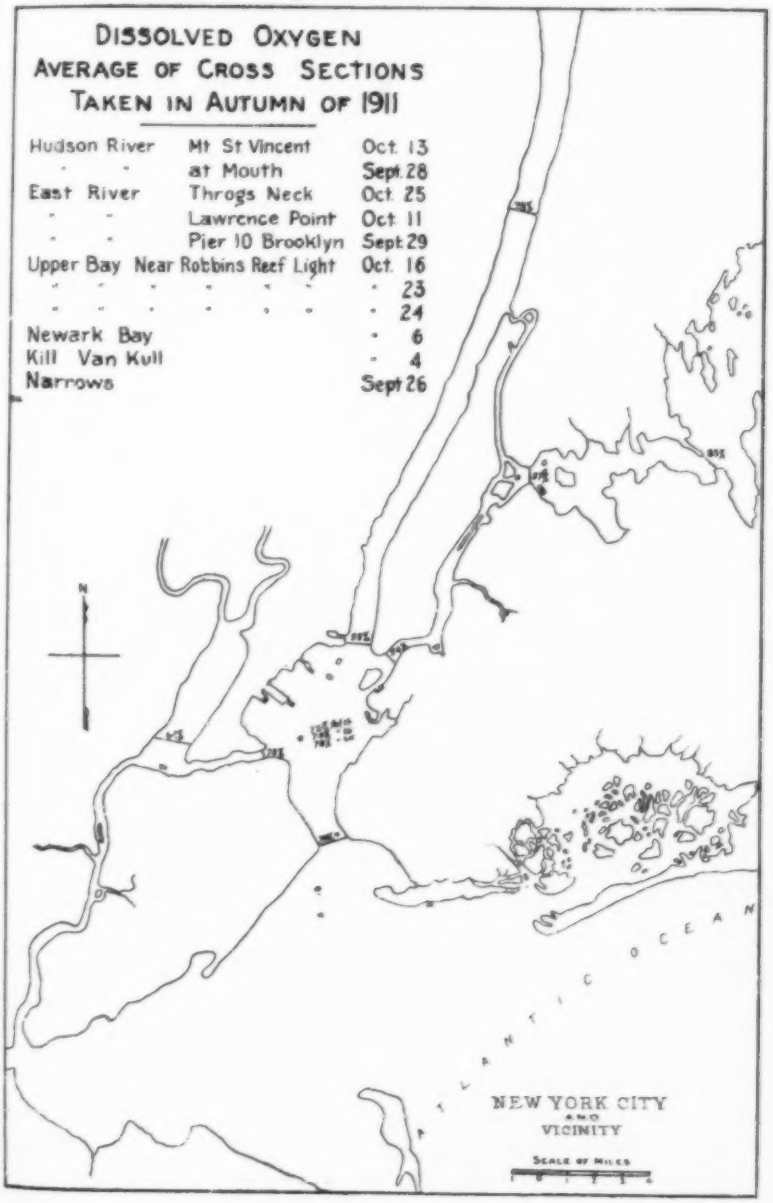


Fig. 5

2093-Z-307

Complainants Exhibit No. 133,
James D. Maher
Commissioner.



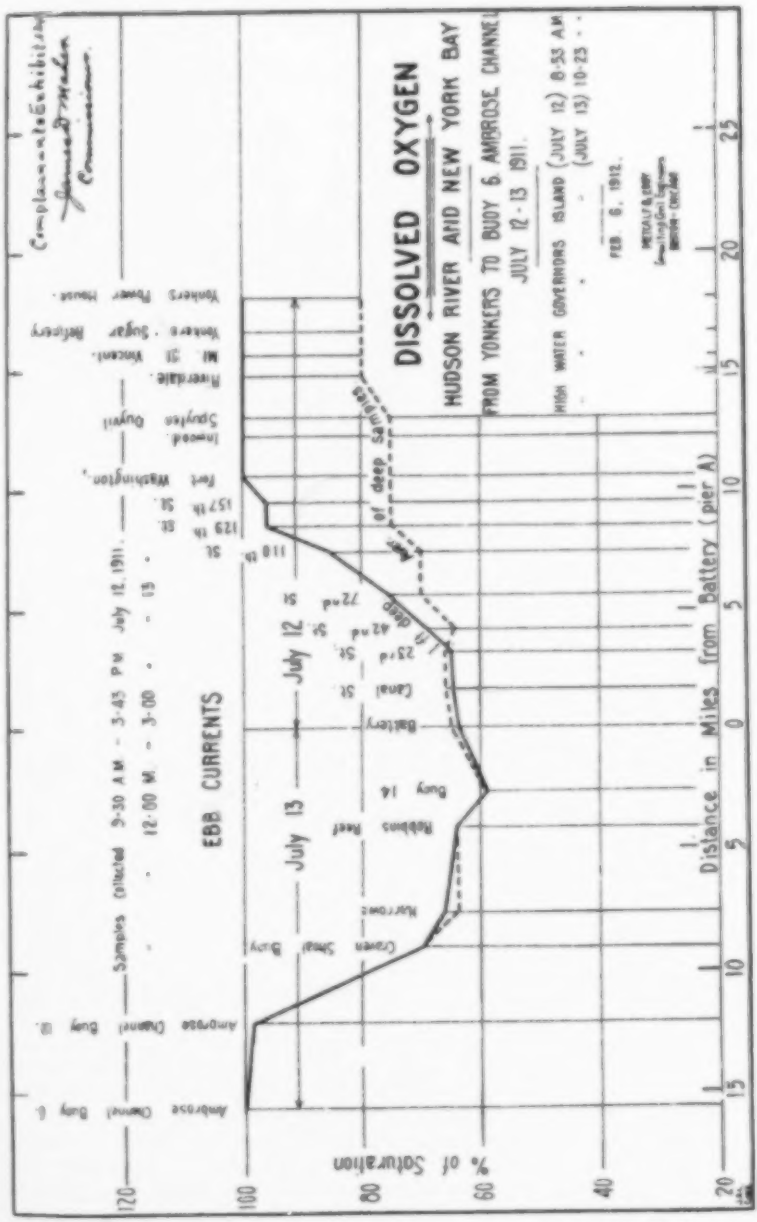


Fig. 7

2055-Z-251

1 COMPLAINANTS' EXHIBIT No. 135. James D. Maher, Commissioner.

In the Supreme Court of the United States, October Term, 1909.

In Equity. No. 6, Original.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants; THE UNITED STATES, Intervenor.

It is hereby stipulated by and between the United States, intervenor in the above entitled cause, and the State of New Jersey and Passaic Valley Sewerage Commissioners, defendants in said cause, that the petition of intervention by the United States in said cause be forthwith dismissed without prejudice.

GEO. W. WICKERSHAM,
Attorney General of the United States.
ROBERT H. McCARTER,
Special Counsel for State and for Edmund Wilson, Attorney General of the State of New Jersey.
CHANDLER W. RIKER,
Solicitors for and of Counsel with Passaic Valley Sewerage Commissioners.

2 In the Supreme Court of the United States, October Term, 1909.

In Equity. No. 6, Original on the Docket for said October Term.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Stipulation.

The United States having intervened in the above entitled suit with the consent of the court, and it being desired by the United States and the defendants in the suit to adjust the matters in controversy between them, in the manner and upon the terms and conditions hereinafter stated, and the State of New Jersey, by an act of its Legislature, approved on the eighth day of April, nineteen hundred and ten, having authorized the defendant, the Passaic Valley Sewerage Commissioners, to make this adjustment, it is now stipulated and agreed by and between the United States and the

Passaic Valley Sewerage Commissioners, defendants in the suit, as follows:

First. The Passaic Valley Sewerage Commissioners agree with the United States that the sewer system to which the suit relates shall be constructed, maintained and operated if at all, in accordance with the following requirements:

(a) Upon the line of the trunk sewer which it is proposed shall be constructed, and at a point at or near the pumping station to be located on the Newark Meadows near the Newark Bay, it is stipulated and agreed that the sewage, waste and other matter passing through the said trunk sewer shall first pass through coarse screens
3 to remove therefrom all large floating matter, and after passing through such coarse screens shall pass through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage and other matter shall pass through self-cleansing mechanical screens having clear openings of not over 4/10 of an inch.

(b) As the sewage comes from the fine screens, it shall also pass through sedimentation basins. The sewage after passing through said grit basin and said self-cleansing mechanical screens shall enter the sedimentation basins or settling tanks consisting of a number of units, each approximately 225 feet long and 15 feet deep. Each tank will have a normal capacity of not less than 1,250,000 gallons, making an aggregate tank capacity sufficient to meet the requirements as stated herein. The tank capacity shall always be such as to provide a detention period of not less than one hour at the maximum rate of flow of the sewage and a detention period of the daily average flow of such sewage for not less than one hour and a half. The mean lineal velocities through said tanks shall not be over 0.5 inch per second for average flow, and 0.75 inch per second for the maximum flow. In addition to and in connection with these basins scum boards shall be provided to retain the floating matter, and proper and adequate devices shall be used to remove the retained scum and deposits from the settling basins; drawings of the general plan of said settling tanks (sedimentation basins) as proposed at the outset being herewith attached as Appendix A.

(c) The sewage and waste thus screened and settled is then to flow into a pump well, whence it is to be pumped under pressure through a tunnel to a point in the New York Bay near Robbins Reef Light, at which point it is agreed that the matter passing through the said tunnel shall be dispersed into the waters of the New York Bay through a series of outlets discharging forty feet or more beneath the surface of the water at mean low tide. From the end of the tunnel connections shall be made with four or more dis-
4 charge pipes extending across the current, spaced about one hundred feet apart, laid in trenches on the bottom of the Bay, and of a size decreasing in diameter from about six feet to two feet. On the top of these discharge pipes will be a series of not less than one hundred and fifty tees of a diameter not exceeding one foot, and spaced approximately ten feet apart. On each of these vertical tees shall be placed outlets arranged to discharge horizontally across

the tidal current, and the extent of the dispersion area used for this system of outlet pipes shall cover at least 3.5 acres of the bottom of the Bay.

Second. The Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system at all times the following results shall be secured, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements, viz:

(1) There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage.

(2) There will be absence of deposits objectionable to the Secretary of War of the United States in the New York Bay coming from the Passaic Valley sewage.

(3) There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

(4) There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere.

(5) There will be no injury to the public health which will be occasioned by the discharge from the said sewer into the Bay of New York in the manner proposed and no public or private nuisance will be created thereby.

(6) The absence of injurious effect from said sewage discharge upon the property of the United States situated in the Harbor of New York.

(7) The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life.

Third. The said Passaic Valley Sewerage Commissioners further agree with the United States that so long as said sewer system, or any part thereof, is operated, the United States shall have, through such representatives as may be designated by the Secretary of War at any time for such purpose, full opportunity to inspect the condition and working of the sewer system, with a view to determining whether this contract is being in all respects performed, and that the said Passaic Valley Sewerage Commissioners will render such expert or other assistance as the United States may desire in the course and in aid of such inspection and determination.

Fourth. The United States agrees with the Passaic Valley Sewerage Commissioners that forthwith upon the filing of this agreement, properly executed, in the office of the Clerk of the Supreme Court as a stipulation of the parties in the suit, it will discontinue its intervention in the above entitled suit and will cause its petition of intervention to be dismissed without prejudice, and will not again intervene in said suit.

Fifth. The United States and the Passaic Valley Sewerage Commissioners mutually agree that this contract shall not become effective in any part, except the next succeeding divisions, unless or until all such permits as would be requisite under the statutes of the United

States for the construction, maintenance or operation of said sewer system without this contract are actually obtained from the United States, or unless or until such permits are made conditional upon compliance at all times with all the terms and requirements of the divisions of this contract numbered First and Second, whether or not such permits contain other terms or conditions.

6 Sixth. The Passaic Valley Sewerage Commissioners hereby consent that full compliance at all times with the terms and requirements of the First and Second divisions of this contract be made express conditions of any permits issued by or on the part of the United States for construction, maintenance or operation of said sewer system, and agree with the United States that this contract shall establish such consent before all officers of the United States.

Seventh. It is agreed between the United States and the Passaic Valley Sewerage Commissioners that this contract shall bind and also shall enure to the benefit of the successors of the latter.

In witness whereof this instrument has been executed in triplicate: being signed in the name and on behalf of the United States by the Attorney General of the United States and in the name and on behalf of the Passaic Valley Sewerage Commissioners by their president, and being sealed also on behalf of said Passaic Valley Sewerage Commissioners, with their corporate seal attested by their secretary; all on the fourteenth day of April, nineteen hundred and ten.

THE UNITED STATES OF AMERICA,
By GEO. W. WICKERSHAM,
Attorney General.

[SEAL.] PASSAIC VALLEY SEWERAGE COMMISSIONERS,
By JULIUS A. LEBKUECHER,
Chairman and President.

Attest:

JOHN S. GIBSON,
Secretary and Clerk.

7 In the Supreme Court of the United States, October Term, 1909.

In Equity. No. 6, Original.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants; THE UNITED STATES, Intervenor,
vs.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

In behalf of the State of New Jersey, I approve of and consent to the making of the foregoing stipulation, and consent that the United States discontinue its intervention in the above entitled cause,

and that the petition of intervention of the United States be dismissed wihout prejudice.

Dated April 14, 1910.

ROBERT H. McCARTER,
Special Counsel.

A true copy.
Test:

[Seal of the Supreme Court of the United States.]

JAMES H. McKENNEY,
Clerk of the Supreme Court of the United States.

8 Copy of Agreement Between U. S. and N. J.

In the Supreme Court of the United States, October Term, 1909.

In Equity. No. 6, Original on the Docket for said October Term.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,
v.
THE STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

Stipulation.

The United States having intervened in the above entitled suit with the consent of the court, and it being desired by the United States and the defendants in the suit to adjust the matters in controversy between them, in the manner and upon the terms and conditions hereinafter stated, and the State of New Jersey, by an act of its Legislature passed on the — day of January, nineteen hundred and ten, and approved by the Governor of the State on the — day of January, nineteen hundred and ten, and having authorized the Attorney General of the State and the defendants, the Passaic Valley Sewerage Commissioners, to make this adjustment on behalf of the State of New Jersey and the said Sewerage Commissioners, it is now stipulated and agreed by and between the United States and the defendants in the suit as follows:

First. The State of New Jersey and the Passaic Valley Sewerage Commissioners agree with the United States that the sewer system to which the suit relates shall be constructed, maintained and operated, if it all, in accordance with the following requirements:

9 (*a*) Upon the line of the trunk sewer which it is proposed shall be constructed, and at a point at or near the pumping station to be located on the Newark Meadows near the Newark Bay, it is stipulated and agreed that the sewage, waste and other matter passing through the said trunk sewer shall first pass through coarse screens to remove therefrom all large floating matter, and after passing through such coarse screens shall pass through a grit basin or

4009

basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage and other matter shall pass through self-cleansing mechanical screens having clear openings of not over 4/10 of an inch.

(*b*) As the sewage comes from the fine screens, it shall also pass through the sedimentation basins. The sewage after passing through said grit basin and self-cleansing mechanical screens shall enter the sedimentation basins or settling tanks consisting of a number of units, each approximately 225 feet long and 15 feet deep. Each tank will have a normal capacity of about 1,250,000 gallons, making an aggregate tank capacity sufficient to meet the requirements as stated herein. These tanks shall provide a detention period at the maximum rate of flow of the sewage when the sewer goes into operation and begins to discharge into the said waters, and until the year 1920, of not less than one hour, with a capacity and provision for the detention of the average flow of such sewage for not less than one hour and a half in the year 1920. The main lineal velocities through said tanks when said sewer begins to discharge, and until 1920 shall not be over 0.5 inch per second for average flow, and 0.75 inch per second for the maximum flow. In addition to and in connection with these basins scum boards shall be provided to retain the floating matter, and proper and adequate devices shall be used to remove the retained scum and deposits from the settling basins; drawings of the general plan of said settling tanks (sedimentation basins) being herewith attached as Appendix A.

(*c*) The sewage and waste thus screened and settled is then to flow into a pump well, from whence it is to be pumped under pressure through the tunnel to a point in the New York Bay near Robbins Reef light, at which point it is agreed that the matter passing through the said tunnel shall be dispersed into the waters of the New York Bay through a series of outlets discharging forty feet or more beneath the surface of the water at mean low tide. From the end of the tunnel connections shall be made with four or more discharge pipes extending across the current, spaced about one hundred feet apart, laid in trenches on the bottom of the Bay, and of a size decreasing in diameter from about six feet to two feet. On the top of these discharge pipes will be a series of not less than one hundred and fifty tees of a diameter not exceeding one foot, and spaced approximately ten feet apart. On each of these vertical tees shall be placed outlets arranged to discharge horizontally across the tidal current and the extent of the dispersion area used for this system of outlet pipes shall cover at least 3.5 acres of the bottom of the Bay.

Second. The State of New Jersey and the Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system, provided the permits for its construction referred to in Article V of this instrument have been granted, at all times the following results shall be secured, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements, viz:

(1) There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage.

(2) There will be absence of deposits objectionable to the Secretary of War of the United States in New York Bay coming from the Passaic Valley sewage.

(3) There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

(4) There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere.

(5) There will be no injury to the public health which will be occasioned by the discharge from the said sewer into the Bay of New York in the manner proposed and no public or private nuisance will be created thereby.

(6) The absence of injurious effect from said sewage discharge, upon the property of the United States situated in the Harbor of New York.

(7) The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life.

Third. The State of New Jersey and said Passaic Valley
12 Sewerage Commissioners further agree with the United States that so long as said sewer system or any part thereof, is operated, the United States shall have through such representatives as may be designated by the Secretary of War at any time for such purpose, full opportunity to inspect the condition and working of the sewer system, with a view to determining whether this contract is in all respects performed, and that the said Passaic Valley Sewerage Commissioners will render such expert or other assistance as the United States may desire in the course and in aid of such inspection and determination.

Fourth. The United States agrees with the State of New Jersey and the Passaic Valley Sewerage Commissioners that forthwith upon the filing of this agreement, properly executed, in the office of the Clerk of the Supreme Court as a stipulation of the parties in the suit, it will discontinue its intervention in the above entitled suit and will cause its petition of intervention to be dismissed without prejudice, and will not again intervene in said suit.

Fifth. The United States and the State of New Jersey and the Passaic Valley Sewerage Commissioners mutually agree that this contract shall not become effective in any part except the next succeeding division, unless or until all such permits as would be requisite under the statutes of the United States for the construction, maintenance or operation of said sewer system without this contract are actually obtained from the United States, or unless or until such permits are made conditional upon compliance at all times with all the terms and requirements of the divisions of this contract
13 numbered first and second, whether or not such permits contain other terms or conditions.

Sixth. The State of New Jersey and the Passaic Valley Sewerage Commissioners hereby consent that full compliance at all times with the terms and requirements of the first and second divisions of this contract be made express conditions of any permits issued by or on the part of the United States for construction, maintenance or operation of said sewer system, and agree with the United States that this contract shall establish such consent before all officers of the United States.

Signed in triplicate in the name and on behalf of the United States by the Attorney General of the United States and in the name and on behalf of the State of New Jersey by its Attorney General and in the name and on behalf of the Passaic Valley Sewerage Commissioners by their president, and sealed also on behalf of said Passaic Valley Sewerage Commissioners with their corporate seal, attested by their secretary; all on the — day of —— Nineteen hundred and ten.

[Endorsed:] Complainants' Exhibit 135. James D. Maher, Commissioner.

1 COMPLAINANTS' EXHIBIT No. 136. James D. Maher, Commissioner.

Board of Estimate and Apportionment.

Report of Col. William M. Black, U. S. A., and Prof. Earle B. Phelps, Concerning Location of Sewer Outlets and the Discharge of Sewage into New York Harbor.

1911.

2 CITY OF NEW YORK:

Report of Colonel William M. Black, Corps of Engineers, U. S. A., and Professor Earle B. Phelps, Concerning the Location of Sewer Outlets and the Discharge of Sewage into New York Harbor, Submitted to the Board of Estimate and Apportionment, March 23, 1911.

3 Table of Contents.

	Page
Final Report	5
Report on Corona Drainage District	99
Report on Flushing Drainage District	115
Report on Jamaica Drainage District	125
Report on Richmond Drainage District	151
Report on Oxygen Content of Sea Water as a Standard for Measuring Sewage Pollution	185

4 BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, March 14, 1911.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment.

SIR: I beg to submit herewith the final report of Colonel William M. Black and Professor Earle B. Phelps, giving the result of their investigation as to the location of sewer outlets and the discharge of sewage into the waters about New York, which was authorized by resolution adopted by the Board of Estimate and Apportionment on November 12, 1909.

Five preliminary reports have already been submitted to the Board, as follows:

1. Drainage of Flushing District, April 22, 1910.
2. Drainage of Corona District, June 17, 1910.
3. Oxygen content as a standard, July 1, 1910.
4. Drainage of Jamaica District, January 12, 1911.
5. Drainage of Richmond District, March 9, 1911.

The present report gives the general result of their study of the circulation of the waters in the harbor and the capacity of these waters to receive sewage without undue pollution, with recommenda-

tions as to the standard of purity which should be maintained in the different portions of the harbor. These studies are based upon the constitution of the water in the different portions of the harbor as the result of the tidal movements and the mixture of sewage bearing waters with clean sea water entering the harbor from the sea at Sandy Hook and from Long Island Sound at Throgs Neck, and the water from the Hudson River, which is already more or less polluted. For the purpose of this investigation and the computations they have divided the harbor into seven different areas, namely, the Lower and Upper Bays, the Hudson River, below and above Ninety-sixth street, the East River, below and above Hell Gate, and the Harlem River.

The degree of pollution and the capacity of the harbor waters to care for additional sewage is expressed in terms of the dissolved oxygen remaining in the water, and the recommendation in this final report is that 70 per cent. of the saturation value of dissolved oxygen would be a proper standard of purity to be maintained if possible.

The report contains a discussion of the renewal of the oxygen content of water by absorption from the atmosphere and by aeration through disturbances caused by wind, by passing vessels, and by tidal currents. It appears to be conclusively shown that the extent of the renewal of the normal oxygen content by these agencies has been greatly overestimated, and that their effect is so slight as to be almost negligible. The belief is expressed that were all the sewage of the City discharged at Throgs Neck or at the Narrows, that is, at the points of entrance of unpolluted sea water into the harbor, a safe limit of pollution could be maintained without treatment of the sewage until the population shall have reached more than 7,000,000. It is also believed that crude sewage can safely be discharged in the vicinity of Riker's Island or the Narrows for some years to come, but that at other points partial purification will soon be necessary, at least during the summer months, while even with such partial purification a proper system of discharge and dispersion will be necessary.

The report gives the results of a series of experiments to determine the practicability of a system of forced aeration following a short period of septic treatment, the estimated cost of which is given at $2.00 per million gallons of sewage treated, with the probability of a material reduction as the result of further experiment. The suggestions in this and previous reports as to the details of the sewerage plans for different parts of the City must not be considered as anything more than suggestions, but they appear so reasonable that it is believed that they will be found in their general features to be logical and practicable and along lines which will commend themselves to the several Borough Presidents in the completion of their drainage plans.

The amount of work which has been done within the limits of time and funds which were available is quite remarkable, and these results could not have been obtained except for the fact that the investigations of the United States Coast and Geodetic Survey and

of the United States Engineer Corps were fully availed of. In discussing the question of the pollution of the waters of the harbor and the necessity for treating sewage discharging into them, the absence of any accepted standard by which the degree of pollution and the necessity for treatment could be judged, has been a serious handicap. It may be that the use of the percentage of the saturation value of dissolved oxygen will furnish a standard which can be generally accepted. Colonel Black and Professor Phelps have suggested that 70 per cent. of this value would be a proper standard of purity which the City should endeavor to maintain, but they admit that this whole matter is one upon which there is at present much difference of opinion, and I believe that if this question could be submitted to a committee of especially qualified engineers for a report as to a proper standard for the harbor waters, the conclusion of such a committee would be accepted not only by the City of New York, but by other cities similarly situated, and that a valuable contribution would be made to the vexed subject of the protection of navigable waters from undue pollution by the sewage of great seacoast cities.

The experiments already referred to may, if continued, produce results of considerable economic value. They were started at the Twenty-sixth Ward sewage disposal plant, in the Borough of Brooklyn, and they could be continued at this plant under the supervision of the President of the Borough of Brooklyn at an expense which would be small in comparison with the value of the results which may be attained. An enlargement of this plant will probably be necessary in the near future, and in planning such enlargement provision could well be made for experimental work on the lines suggested.

I would recommend that the Board appoint a commission of five engineers, to consist of Colonel William M. Black, a representative to be designated by the Metropolitan Sewerage Commission, and three others who are generally recognized as authorities in this particular field of engineering work, and that such commission be instructed to advise the Board of Estimate and Apportionment at as early a date as possible of their conclusions as to the percentage of the saturation value of dissolved oxygen which the City should strive to maintain in the waters of the harbor of New York.

I would also recommend that the President of the Borough of Brooklyn be requested to continue the investigations inaugurated by Colonel Black and Professor Phelps to determine the feasibility of an economic application of the treatment of sewage by forced aeration, and to advise the Board of the result of such investigations and experiments.

It is further recommended that the Secretary be authorized and directed to have five hundred (500) copies of this report printed as a pamphlet, together with the five preliminary reports as appendices.

Respectfully,

NELSON P. LEWIS,
Chief Engineer.

6 NEW YORK, February 16, 1911.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, 277 Broadway, New York City.

SIR: We have the honor to submit the following final report of the work done under the directions contained in your letters of October 11 and November 18 and 20, 1909, and the terms of acceptance named in the letter of Colonel Black, dated December 21, 1909.

In brief, the problems laid before us were to determine the most advantageous points for sewage discharge for the areas draining into the East River from the districts of Greater New York on Long Island to the east of Newtown Creek; for the portion of the Borough of The Bronx draining into the same waterway; for the drainage areas tributary to Jamaica Bay, including Far Rockaway and Coney Island, and for the Borough of Richmond; and further, to determine the degree of purification, if any, to which the sewage would have to be subjected before discharge in order that the waters in question should not be polluted unduly thereby.

The solution of the problems involves:

1. The determination of a standard of purity for the harbor waters.

2. A study of the circulation of these waters through the various parts of the harbor, with a view to determining for each part the general constitution of the waters in that part during any one tidal period, what proportion of the total volume had come direct from the unpolluted waters of the sea or Sound and what proportion from other parts of the harbor, where, for a greater or less period, they had been receiving sewage.

3. A study of the capacity of the waters of each part to receive sewage without undue pollution, including in this a study of the sources of supply of oxygen.

4. A study of an economical method of partial purification, applicable to the conditions of New York.

5. A study of the terrain of the various districts, of present and expected population, of the drainage areas from which sewage can be collected, of the lines along which it can be moved for disposal, of the volumes of sewage to be provided for, of the available points for discharge, and finally for each district, of the degree of purification demanded by the capacity of the portion of the harbor in question to care for the sewage without undue pollution.

For this work one year's time and $10,000 were available. It was found that under these conditions the field work had to be limited to the determination of the dissolved oxygen in the waters at the harbor entrances and to the experimental work required to develop the method of partial purification. In the studies, existing maps had to be used for the terrain and existing data for the circulation of the waters in the harbor.

The results of our investigations may be briefly summarized as follows:

(1) The amount of dissolved oxygen in the harbor waters furnishes the most satisfactory criterion of the purity of these waters.

We believe that this natural purifying agent should not be
7 drawn upon to an extent which will reduce it below 70 per cent. of the full saturation value. This standard of purity refers not only to average conditions throughout the harbor and its tributaries, but also to the average condition within any of the sub-areas into which for the purposes of this study we have divided these waters.

(2) We have shown that the circulation of water through these various sub-areas makes the condition of each dependent to a large extent upon the conditions in one or more of the others. We have determined these complex relationships with a reasonable degree of accuracy and in this way have been able to determine the most suitable points for sewage discharge and the probable effect of such discharge not only upon the area immediately adjacent, but upon the entire body of water under consideration. If the sewage of the entire drainage area tributary to these waters could be concentrated at the two entrances, namely, at the Narrows and Throgs Neck, we estimate that the standard of purity laid down could be maintained, for the present at least, and for the immediate future until such a time that the population of this entire district has reached 7.4 millions. Such an arrangement would develop the fullest use of the natural purifying agencies. Any other system of discharge will result, even under present conditions of population, in the production of local conditions below our proposed standard. That standard can be maintained at present by purifying the sewage which enters these waters at other points than those indicated to a degree which will reduce its oxygen requirements to one-third their present value.

(3) The partial purification proposed in the last sentence will maintain our proposed standard of purity also in each of the several sub-areas considered, providing a proper system of discharge and dispersion be employed in each case. Under the present unsatisfactory method of discharge local nuisances are created and would continue to exist even after the purification which we have indicated had been established. These are due not to insufficient volumes of water as compared with the volume of sewage discharged, but to the fact that the fullest use of this water cannot be attained under existing conditions. In studying the sources of oxygen available for purification we have found that a serious misconception exists of the importance of reaeration by partially de-aerated waters. We have determined that this reaeration factor is one that is without material significance in the case of the waters of New York Harbor.

(4) We have determined by experiments upon a practical scale made both at Brooklyn and at Boston, that a degree of purification which will reduce the oxygen requirements of the sewage to one-third their present value during the summer months, can be obtained by a short period of septic treatment followed by forced aeration. The cost of such treatment will not exceed all told two dollars per million gallons, and further studies will doubtless make it possible to reduce this cost materially.

(5) Our studies of main drainage schemes are included in four appendices to this report and summarized in Chapter IV. herein.

Separate schemes are submitted for the four drainage areas designated, Flushing, Corona, Jamaica and Richmond Drainage Area, respectively.

These studies were necessary in order that feasible points of discharge might be located and they have been worked out only in detail sufficient to determine the feasibility of our proposed discharge points. While they have been made to conform as far as possible with existing and proposed works, they are in no sense offered as complete or final drainage plans. We have shown the most
8 advantageous point of final discharge in each case and the feasibility of concentrating the drainage of the district at these points. If better lines and grades exist they can undoubtedly be found by a proper and thorough study of the situation.

The problems involved are of great magnitude and the importance to New York of their correct solution can hardly be exaggerated. In presenting this, their final report, the writers realize its incompleteness as regards some of the questions involved. They feel, however, that the lines they have followed are correct and that their studies will at least make more plain the path for further investigation.

We recommend that further investigations be directed along the following lines:

(1) The establishment of a standard of purity upon a firmer basis of fact than that which now exists. We realize fully that this standard is the foundation stone of our work; we also realize that this whole matter is one upon which there are differences of opinion and that these opinions have but a slight satisfactory basis of observed facts. This is a matter which should be made the subject of the most thorough investigation possible, the results of which should be submitted to the impartial judgment of a commission of engineers for final settlement.

(2) We further recommend, in view of the favorable results of our experimental work, that the Twenty-sixth Ward Disposal Plant be equipped for the purification of the sewage now flowing through it by the process of aeration which we have developed in order that the merits and economy of this process may be more fully and finally determined. This project should in no sense be regarded as an experiment, since the process has already been carried through the experimental stage, and since, as we have shown, some purification of the sewage from this district will be required in the near future. At the same time the results obtained at this plant and the improvements in the process which will necessarily result from a careful study of the proposed plant, will be of immediate value in the solution of the final problem of disposal at other points throughout the Greater City.

(3) Finally, we recommend a careful study of the whole matter of sewage discharge with reference to the proper dispersion of the sewage stream in the body of water into which it flows. Neglect of this matter is bound to result in serious local nuisances and will

render it impossible to utilize to the point of fullest economy the natural purifying agencies which exist.

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

9 *Capacity of New York Harbor to Receive and Reduce Sewage.*

By W. M. Black, Colonel, Corps of Engineers, U. S. A., Member, American Society of Civil Engineers and Earle B. Phelps, professor of Chemical Biology, Massachusetts Institute of Technology; Consulting Sanitary Engineer, Assoc. American Society of Civil Engineers, February 16, 1911.

10 *Contents of Final Report.*

CHAPTER I.—	PAGE
Study of Circulation of Harbor Waters and Their Capacity to Receive Sewage Without Undue Pollution:	
Standard of Purity for the Harbor Waters	17
Circulation of Waters in New York Harbor	18
Capacity of Harbor Waters to Receive Sewage Without Undue Pollution	33
CHAPTER II.—	
Absorption of Atmospheric Oxygen by Water:	
Quiescent Water:	
Discussion of the Problem	39
Theoretical and Experimental	40
Results	42
Application	49
Salt Water Conditions	50
The "Streaming Effect"	50
Conclusions Regarding Quiescent Water	52
Effect of Currents and Other Disturbing Factors Upon the rate of Aeration:	
Effect of Wind	56
Effect of Passing Vessels	59
Effect of Tidal Currents	60
Summary and Conclusions	62
CHAPTER III.—	
Investigations Into the Aeration of Sewage:	
General	64
Aeration of Crude and Septic Sewage in Shallow Tanks:	
Plan of Investigations	64
Chemical Methods	65
Results Obtained	68

Chemical Analyses 69
Relative Stability 70
Putrescibility Co-efficient, K..... 71

Aeration of Septic Sewage in a Deep Tank:
Plan of Investigations..... 72
Results Obtained 72

Experiments Upon the Aeration of a Biolytic Effluent at Boston, Mass.:
Plan of Investigations..... 75
Results 75

Conclusions:
Amount of Air Required and Improvement Effected 76
Sludge 77
Cost 77

11 CHAPTER IV.—

Projects for Sewage Concentration and Discharge:
Flushing Drainage District..... 79
Corona Drainage District..... 79
Jamaica Drainage District..... 80
Borough of Richmond Drainage District..... 83
Part of Borough of Bronx Drainage District..... 85

CHAPTER V.—

General Remarks and Recommendations..... 86

APPENDIX—

Determination of the Rate of Absorption of Oxygen by Water 89
Mathematical 89
Experimental 93
Results 94

Tables.

No. 1. Flow through various sections..... 27
No. 2. Changes of water surface during tidal periods..... 28
No. 3. Volumes in harbor areas..... 30
No. 4. Formulæ showing composition of waters at end of flood and ebb in proportions of volumes of tributary areas 32
No. 5. Formulæ in volumes from various sources..... 32
No. 6. Formulæ showing percentages of the volumes in an area, derived from various sources..... 33
No. 7. Table of population and sewage flow emptying into harbor waters 35
No. 8. Volume of oxygen available by reaeration in six hours 35

No. 9. Dilution ratios and resulting perventages of oxygen under existing conditions..... 36
No. 10. Dilution ratios and regulating percentages of oxygen with partial purification..... 37
N. 11. Dilution ratios and resulting perventages of oxygen with sewage discharged at the Narrows and Throgs Neck entrances..... 38
No. 12. Amount of oxygen absorbed from atmosphere by fresh water, in per cent. of saturation..... 43
No. 13. Amount of oxygen absorbed from atmosphere by fresh water in pounds per million gallons..... 44
No. 14. Average rate in pounds per hour of oxygen absorbed per million gallons fresh water..... 52
No. 15. Effect of wind in producing mixing in New York Harbor..... 58
No. 16. Frequency of wind storms, New York Harbor.... 58
No. 17. Frequency of mixing, by wind, in New York Harbor 59
No. 18. Movement of vessels, New York Harbor..... 60
No. 19. Average rate of absorption of oxygen by waters of New York Harbor..... 62
No. 20. Analyses of Boston sewage..... 68
No. 21. Relative stability, etc., crude, septic and aerated sewage..... 70
No. 22. Percentage of improvement by aeration..... 71
No. 23. Relative stability, crude and aerated sewage..... 73
No. 24. Tidal data, Arthur Kill..... 83

Plates and Diagrams.

No. 1. Map of New York Harbor..... 19
No. 2. Mean tidal and velocity curves the Narrows..... 20
No. 3. Mean tidal and velocity curves Forty-second street, Hudson River..... 21
No. 4. Mean tidal and velocity curves Nineteenth street, East River..... 22
No. 5. Mean tidal and velocity curves Throgs Neck, East River..... 23

12

No. 6. Mean tidal curves New York Harbor..... 24
No. 7. Tidal slopes between Sandy Hook and Throgs Neck 25
Diagram 5. Oxygen (pounds) absorbed at stated depth dur- fresh water during various periods, depth 5 feet..... 45
Diagram 2. Same for 10-foot depth..... 46
Diagram 3. Same for 15-foot depth..... 47
Diagram 4. Same for 20-foot depth..... 48
Diagram 5. Oxygen (pounds) absorbed at stated depths during various periods..... 53

Diagram 6. Average rate in pounds per hour of absorption of oxygen from atmosphere per million gallons at stated depths during certain periods..... 54
Diagram 8. Actual hourly rate of absorption of oxygen from the atmosphere at any time per million gallons at stated depths..... 55
Diagram 7. Depths to which wind storms of various velocities produce mixing..... 57
Diagram 9. Relation between velocity Constant K and absorption of disolved oxygen by sewage..... 67
Diagram I. App. Apparatus for determining diffusion co-efficient .....opp. p. 93
Diagram II. App. Diffusion co-efficient..... 96
Diagram III. App. Value of K-Range, K=0.000 to 0.001.. 97
Diagram IV. App. Value of K-Range, K=.001 to 0.01.... 98
Map showing drainage lines and points of discharge recommended for Flushing, Corona, Jamaica and Borough of Bronx Districts 140
Map showing same for Borough of Richmond..... 183

13 Chapter I.

I. Standard of Purity for the Harbor Waters.

It is only within recent years that well-founded complaints have been made about the foulness of the harbor waters. As yet, to the superficial observer, only small portions of these waters are manifestly in a condition to be regarded as a nuisance. The condition has come gradually and with the increase of population. The increase continues, and it is certain that unless remedial measures are taken greater and greater portions of the harbor will be reduced to the conditions of the Gowanus Canal, for example. For years the capacity of the harbor waters was sufficient to receive and digest without injury the sewage of the population of the harbor drainage area. Gradually the volume of sewage poured into them and into the rivers tributary to them has increased until to-day the higher classes of fish have disappeared, bathing in them has become unpleasant, if not dangerous, and portions of them in appearance and smell have more the characteristics of drains than of living waters. From a technical standpoint the most simple measure of the pollution of any waterway is found in the proportion of dissolved oxygen contained therein. Pure, living water contains dissolved oxygen to its saturation value, in an amount which is different for fresh water and for sea water and which varies with the temperature. The amount of oxygen found at saturation in fresh water is 6.38 grains per cubic foot at 32 degrees Fahrenheit and 4.04 grains per cubic foot at 68 degrees. For sea water the corresponding figures are 5.10 grains and 3.29 grains. Sewage as delivered at the sewer mouth is in a highly putrescible condition, and the putrefaction is continued after diffusion in a waterway, robbing the water of its oxygen on

the one hand, but on the other reducing the organic materials of the sewage into stable and innocuous forms. The effect on the water is practically harmless when not used for domestic purposes, until this diminution of its oxygen has continued through a considerable percentage of the saturation volume. For example, probably the first indication of pollution is the disappearance of major fish life, for the existence of which 70 per cent. of the saturation volume of oxygen is necessary. Other forms of fish life can exist until the limit of 30 per cent. has been reached. When the remaining volume of dissolved oxygen in a stream falls below 50 per cent., the stream may at times become turbid and noisome during hot weather, as is illustrated in the Passaic River, in which in the neighborhood of the Pennsylvania Railroad bridge on January 19, 1911, the dissolved oxygen was found to have about 38 per cent. of the saturation value. When reduced below 30 per cent., the condition of the water is such as to constitute a nuisance during the summer season. When any standard is fixed, the amount of sewage which can be poured into the waters without purification is also fixed, though this amount will be greater in winter than in summer on account of the slower rate of putrefaction in cold weather and the greater amount of dissolved oxygen found in the water. Therefore, a higher standard entails greater expense for sewage purification maintenance
14 than a lower. On the other hand, it is practically impossible to obtain or maintain an even diffusion of sewage through the waters of any large waterway. The adoption of a high standard affords greater certainty that no portion of the waterway shall be polluted to a known degree.

After a careful consideration of the whole question, the writers recommend that for New York 70 per cent. of the saturation value be adopted as the standard below which the dissolved oxygen in its harbor waters be not permitted to fall—a standard of which the maintenance can be made evident by the existence of the major fish life formerly so abundant here. The calculations of the capacity of the harbor to receive sewage given hereafter are based on this standard.

2. Circulation of the Waters in the Harbor.

The sources of the harbor waters are the discharge of the streams tributary to them, the direct drainage from the shores and the tidal influx of sea water through the Sandy Hook and Throgs Neck entrances. Originally all of these sources were unpolluted. To-day the streams are polluted by the drainage from the population along their shores. The Passaic is polluted to a degree which has caused an expensive project to be proposed by the State of New Jersey, under which all of the sewage from the district draining into it is to be collected and after partial purification, as required by the United States authorities, is to be discharged into the Upper Bay near Robbins Reef. This project when carried out will better the existing conditions under which these polluted waters are now emptied through Newark Bay and the Kill von Kull, purified only by the comparatively small amount of reaeration and sedimentation they

receive in the passage through Newark Bay. Recent observations made by the United States in a section of the Hudson just above the northern limit of Greater New York show that during the low water period, that stream has been polluted to beyond a safe limit before it reaches the harbor. The direct drainage from the shores is also now a source of pollution. The only unpolluted source of supply is then the sea. Observations made in Ambrose Channel in February, 1910, show that the waters brought in by the flood tide there contain 98 per cent. of the saturation amount of the dissolved oxygen. Other observations at Throgs Neck entrance from the Sound made in January, 1910, show that the ebb (westerly) waters there contain oxygen to 90 per cent. of the saturation value.

Careful observations and analyses of the circulation of the waters in New York Harbor were made by the U. S. Coast and Geodetic Survey through a series of years ending in 1886. Subsequent observations and measurements of the currents in the Harlem have been made by the Engineer Department, U. S. Army. From the record of these observations the following studies have been made.

(Here follow diagrams, of plates 1, 2, 3, 4, 5, 6, 7, marked pages 15 to 21, Complainants' Exhibit 136.)

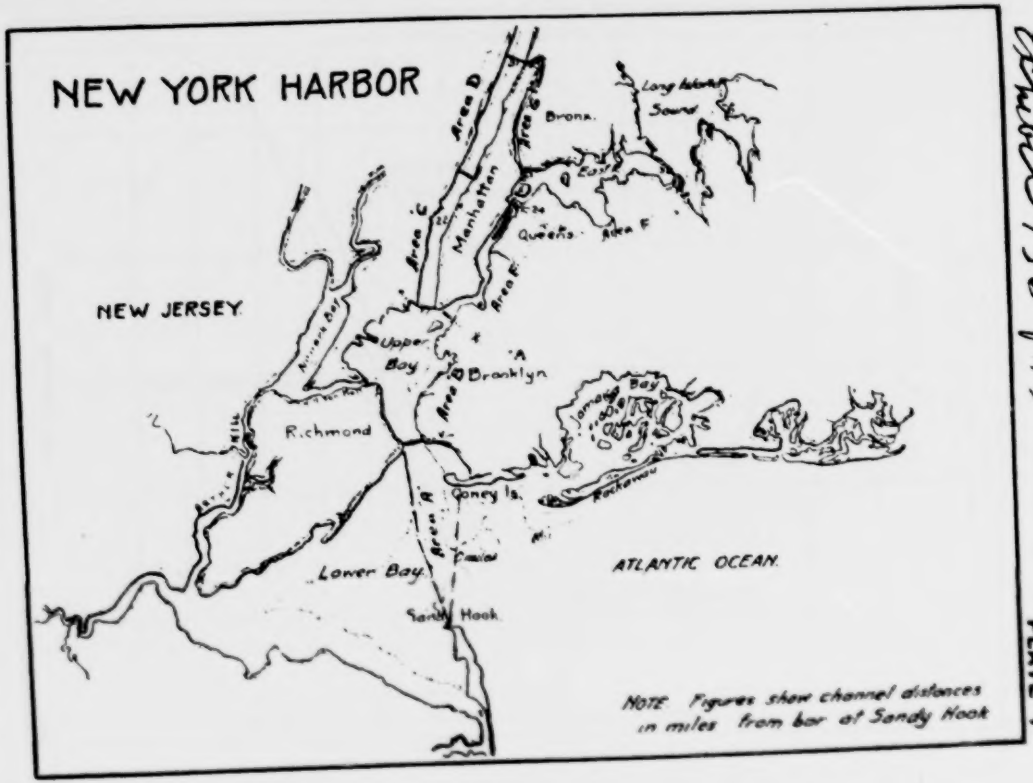


Exhibit 136-p. 115

PLATE 1

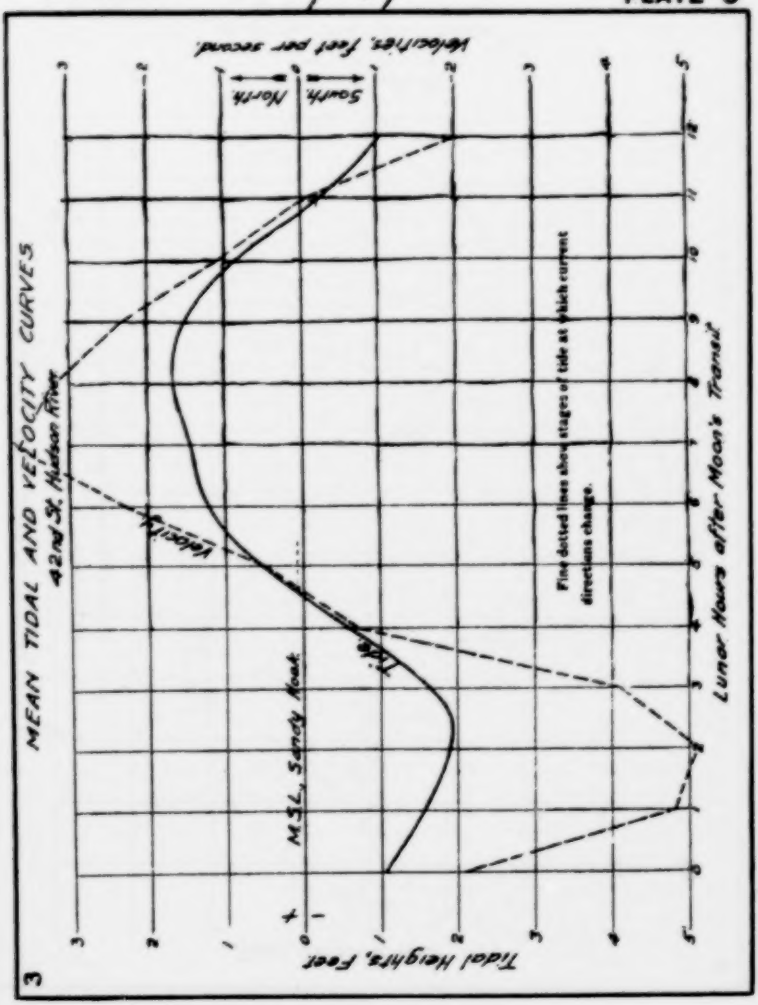
Exhibit 136-p.16

PLATE 2

DARK PAGE BLEE

Exhibit 136-p. 17

PLATE 3



LEED THRU

Exhibit 136-p. 18

PLATE 4

DARK PAGE BL

Exhibit 136-p.19

PLATE 5

LEED THRU

Exhibit 136-p. 20

PLATE 6

DARK PAGE BE

Exhibit 136-p 21

PLATE 7

LEED THRU

Plate No. 1 shows a map of the harbor of New York. The circulation of the waters therein is the result of harbor currents caused by two tidal waves, the crest of one of which reaches Sandy Hook at 7½ hours after the time of lunar culmination, while that of the other arrives at the Throgs Neck entrance from the Sound three hours later. The induced waves meet and interfere over two routes between these points; one via the East River direct and the other via the Hudson, Harlem and East Rivers. The currents are the result of the slopes produced by these waves. A full description of those currents for each lunar hour is printed in Appendix No. 9 of the Report for 1888 of the U. S. Coast and Geodetic Survey, reproduced on pages 158-171 of the Report of the Metropolitan Sewerage Commission of New York for 1910.

Plates Nos. 2, 3, 4 and 5 show the changes in level of the water surface and the velocities and directions of the currents induced in the Narrows, in the Hudson River at Forty-second street, in the East River at Nineteenth street and at Throgs Neck, respectively.

Plate No. 6 shows these tidal curves superposed. In general it may be said that the current directions at any hour between the points for which the curves are given may be determined from the relative elevations of the water surface at those points at that time.

Plate No. 7 shows tidal slopes in the harbor at the time of lunar culmination and six hours later.

The velocities of the currents and the volumes of water will vary with the range of tides on different days. In the Hudson they are also modified by the stage of the river. The shallow and obstructed channels of the Little Hell Gate and Bronx Kills passages between the Harlem and East Rivers cause marked variations in the flow through the Harlem for tides of different ranges, and consequently a difference in the relative volumes passing by the two routes between the Sandy Hook and Throgs Neck entrances to the harbor.

The measurement of the volumes of tidal flow in any channel is difficult, due to the constant variation of velocity through all parts of the section measured and also due to the fact that frequently the currents at the top and bottom of the section are flowing in different directions. The volumes given hereafter for the flow at Sandy Hook and the Narrows and in the East and Hudson Rivers are taken from the reports of the Coast and Geodetic Survey and are the results of calculations by Prof. Henry Mitchell, who was in charge of the observations. To avoid confusion, the currents will be denoted as "ebb" and "flood," respectively, as shown by the direction of the flow with relation to the Sandy Hook entrance. It will be noted then that the term "ebb" at the Throgs Neck entrance will be used for currents from the Sound into the East River, and that the term "flood" at Throgs Neck will denote currents from the East River into the Sound. Similarly, in the Harlem River the term "ebb" will be used for currents flowing north from the East River to the Hudson, and "flood" for currents flowing south from the Hudson into the East River.

The following table will show the volumes assumed for the flow past the sections named, during flood and ebb:

23 TABLE 1.

Sandy Hook—			
Flood	23,322,888,000	cubic	feet.
Ebb	24,658,449,000	"	"
Narrows—			
Flood	12,703,616,480	"	"
Ebb	13,819,805,144	"	"
East River at Nineteenth street—			
Flood	4,007,175,676	"	"
Ebb	4,454,937,257	"	"
East River at Throgs Neck—			
Flood	4,257,000,000	"	"
Ebb	4,689,000,000	"	"
Hudson River at Thirty-ninth street—			
Flood	6,225,985,545	"	"
Ebb	6,996,678,413	"	"
Harlem River at Two Hundred and Sixteenth street—			
Flood	227,531,520	"	"
Ebb	231,840,200	"	"
Kill von Kull—			
Flood	1,712,415,362	"	"
Ebb	1,790,103,372	"	"

For convenience in the following discussion the waters of the harbor have been divided as follows:

A—Lower Bay, east of a line drawn from Sandy Hook through West Bank Light to Fort Wadsworth Light.
B—Upper Bay.
C—Hudson River, from Battery to West Ninety-sixth street.
D—Hudson River, from West Ninety-sixth street to Spuyten Duyvil.
E—East River, from Battery to Hell Gate.
F—East River, from Hell Gate to Throgs Neck.
G—Harlem River.

As exemplified in Plates 2 to 6, the change of current direction from flood to ebb or from ebb to flood does not in all cases coincide with the change in direction of the tidal rise or fall; in other words, does not come at either high or low water. In determining the amount of water flowing into or from any one of these areas during any tidal period it is necessary to compute the volumes with reference to the elevation of the surface plane at the beginning of the period and the change of elevation during the period.

28 TABLE 2.

Showing Changes in Elevation of Water Surface During Flood and Ebb Current Periods Referred to Plane of Mean Low Water.

Area.	Current.	Elevation at beginning of tidal period.	Maximum or minimum elevation; mean range of tide.	Elevation at end of tidal period.
A—Lower bay	Flood..	0.4	4.0	3.4
	Ebb....	3.4	0.0	0.4
B—Upper bay	Flood..	1.7	3.9	2.8
	Ebb....	2.8	0.0	1.7
C—Hudson River, from Battery to Ninety-sixth street	Flood..	2.0	3.6	2.0
	Ebb....	2.0	0.0	2.0
D—Hudson River, from Ninety-sixth street to Spuyten Duyvil	Flood..	2.0	3.6	2.0
	Ebb....	2.0	0.0	2.0
E—East River, Battery to Hell Gate	Flood..	0.0	4.1	4.1
	Ebb....	4.1	0.0	0.0
F—East River, Hell Gate to Throgs Neck	Flood..	4.7	7.2	4.5
	Ebb....	4.5	0.0	4.7
G—Harlem River	Flood..	0.2	4.4	4.2
	Ebb....	4.2	0.0	0.2

An inspection of the map will show that of the areas named, the Hudson River, the East River from the Battery to Hell Gate, and the Harlem River are channels of comparatively regular cross-section in which the current velocity and direction are comparatively uniform from bank to bank; while the areas of the Lower Bay, the Upper Bay and the East River from Hell Gate to Throgs Neck comprise channels with bays or basins filled and emptied from the channels.

The modification which this difference causes in the circulation of the waters is exemplified as follows: When the flood (easterly) current begins in the East River, opposite Old Ferry Point, the water level is at 4.26 feet above the mean low water plane and falling. The mean velocity is given for each lunar hour. While this flood flow continues, the water surface falls from 4.26 feet above mean low water to mean low water and then rises to 4.47 feet above mean low water. The probable effects to the east of Old Ferry Point are that at the end of the flood flow, the entire body of water in the channel east to Stepping Stones Light plus the tidal prism of the bays at the side, to the elevation 4.47, is composed of water, more or less polluted, which had flowed out past Old Ferry Point.

When the ebb current sets in, the water surface is rising, the flow is through the channel and into the bays. As the surface rises, the tidal prism of the bays is completed from the channel and the volume of water flowing back past Old Ferry Point consists of the water which had flowed out, admixed with a volume of normal sound water equal to the amount used in filling the tidal prisms of the side bays plus the preponderance of ebb flows in the East and Harlem Rivers. The volume of this normal sound water thus entering

(about 1,496,222,000 cubic feet), gives the measure of the new supply of oxygen provided by one tide through this entrance. Before the tide turns again this water has been divided between the East and Harlem Rivers and has entered into its work in the harbor.

For the Narrows, when the flow to the south, or the ebb, begins, the water level is at 2.8 feet above the mean low water plane and falling. While the ebb flow continues the surface falls from 2.8 feet above mean low water to mean low water and then rises to 1.7 feet above mean low water.

At the end of this tidal period, the entire body of water in the channel from the Narrows south to the entrance of the Ambrose Channel and on the shoals at either side to the elevation of 1.7 is of that derived from other parts of the harbor.

When the flood current sets in, a circulation similar to that at Throgs Neck takes place. It is estimated that the volume of normal sea water passing through the Narrows during each flood equals 2,398,800,000 cubic feet.

The estimated volumes of water in the various areas are as follows:

TABLE 3.

Locality.	Channel volume, cu. ft.	Tidal area, sq. ft.	Volume of tidal prism, cu. ft., at end of		Total volume, cu. ft. at end of	
			Ebb.	Flood.	Ebb.	Flood.
Lower Bay	10,084,399,200	550,988,700	220,395,480	1,873,361,580	10,304,794,700	11,957,760,800
Upper Bay	11,079,890,000	530,579,340	901,985,000	1,485,622,000	11,981,875,000	12,565,512,000
Hudson River, to Ninety-sixth street	5,109,763,600	140,533,330	281,066,660	281,066,660	5,390,830,300	5,390,830,300
Hudson River, Ninety-sixth street to Spuyten Duyvil	4,546,328,950	148,088,891	296,177,782	296,177,782	4,842,506,700	4,842,506,700
East River, to Hell Gate	3,116,265,700	97,400,500	.....	399,342,050	3,116,265,700	3,515,607,800
East River, Hell Gate to Throgs Neck	6,027,461,580	327,965,179	1,541,436,340	1,475,843,300	7,568,897,900	7,503,304,900
Harlem River	198,752,000	24,674,600	4,934,920	103,633,320	203,686,900	302,385,300

27 An exact determination of the amount of water in any one of the areas at any tidal period derived from the various tributary areas is manifestly impracticable, but it is possible to make an analysis based on reasonable assumptions of flow as shown hereafter; and the reliability of the analysis is susceptible of indirect proof should the determination of pollution obtained thereby agree with the chemical analysis of the waters.

Tests for dissolved oxygen in the harbor waters have been made by the Metropolitan Sewerage Commission at various points, but it does not appear that any series of tests were made through an entire cross-section of any of the channels during an entire tidal period. The results published in the Commission's report are interesting and instructive, but they do not give a certain measure of the average condition of the waters. In September, 1910, under the direction of the United States authorities, Prof. Earle B. Phelps made a series of determinations of dissolved oxygen through a cross-section of the Hudson, opposite Mount St. Vincent, close to the northern city limit and covering nearly an entire 12-hour period. The total number of samples taken was 42. The percentage of sea water varied from 40.5 per cent. to 55.5 per cent., with an average of 42.2 per cent. Dissolved oxygen was found in quantities varying from 39.6 per cent. to 66.8 per cent. of the saturation values, with an average of 51.2 per cent. The effect of this pollution on the harbor capacity for receiving sewage is very apparent in the figures given later for the capacity of the "Upper Hudson" at ebb, and "Harlem" at flood periods.

From the figures given in Table No. 3 for the flow and volume of water in the various areas of the harbor, together with the Coast and Geodetic Survey determinations of velocities, a study was made of the probable sources of the waters in each area at the end of the flood and ebb.*

As an example, the Upper Bay at the end of the ebb is taken.

The ebb flow through the Narrows is known. This water is drawn from the Upper Bay and the waters tributary to it, and these again are replaced by those drawn from sources still further up. The volume in the Upper Bay (channel plus tidal prism volume), at the beginning of the ebb is 12,656,512,000 cubic feet. The ebb flow through the Narrows is 13,819,895,144 cubic feet, giving a remainder of 1,254,383,144 cubic feet, drawn from the Kill von Kull and the Hudson and East Rivers. This was proportioned arbitrarily among the three as seemed just. The volume in the Upper Bay at the end of the ebb is 11,981,875,000 cubic feet. This water is composed entirely of that received from the Kill von Kull, East and Hudson Rivers. Considering the current velocities, it was found that the portion received from the East River comprised all of the water from the Battery to Hell Gate plus a portion of that in the area from Hell Gate to Throgs Neck. Also, that the portion received from the Hudson River was equal to all of that in the area

* The writers are indebted to Mr. W. L. Kuehnle for valuable assistance in this study.

from the Battery to Ninety-sixth street, plus a portion of that in the area from Ninety-sixth street to Spuyten Duyvil. The same method was followed for the other areas. For convenience, these volumes were reduced to percentages and the various volumes were given a characteristic letter.

Let A and A′ represent the water in the Lower Bay east of line joining Sandy Hook, West Bank Light and Fort Wadsworth Light at the end of the flood and ebb, respectively.

28 B and B′ represent the waters in the Upper Bay.

C and C′ represent the waters in the Hudson River from the Battery to Ninety-sixth street.

D and D′ represent the waters in the Hudson River from Ninety-sixth street to Spuyten Duyvil.

E and E′ represent the waters in the East River from the Battery to Hell Gate.

F and F′ represent the waters in the East River from Hell Gate to Throgs Neck.

G and G′ represent the waters in the Harlem River.

Let K denote the waters received from the Kill von Kull.

L the waters received from the Hudson River above Spuyten Duyvil.

M the clean waters received from the Sound at one end and the sea at the other.

Let n denote the tide under consideration, either ebb or flood.

Let n-1 denote the previous tide either floor or ebb.

Let n-2 denote the second previous tide, either ebb or flood.

Table 4

$A_n = 11{,}957{,}760{,}800$ cu. ft. (M)

$B_n = .9868\ A_{n-1} + 2{,}398{,}821{,}800$ cu. ft. (M)

$C_n = .0132\ A'_{n-1} + .4384\ B'_{n-1}$

$D_n = .0697\ B'_{n-1} + .7435\ C'_{n-1}$

$E_n = .2934\ B'_{n-1}$

$F_n = .0410\ B'_{n-1} + E'_{n-1} + .4976\ F'_{n-1} + .6323\ G'_{n-1}$

$G_n = .0094\ C'_{n-1} + .0365\ D'_{n-1} + .3675\ G'_{n-1}$

For the end of the ebb

$A'_n = .6880\ B_{n-1} + .1420\ C_{n-1} + .2220\ E_{n-1} + 113{,}303{,}400$ cu. ft. (K)

$B'_n = .8580\ C_{n-1} + .3316\ D_{n-1} + .7780\ E_{n-1} + 1760\ F_{n-1} + 1{,}676{,}800{,}000$ cu. ft. (K)

$C'_n = .2473\ C'_{n-2} + .1549\ D'_{n-2} + .6684\ D_{n-1} + .2462\ G_{n-1}$

$D'_n = .8088\ D'_{n-2} + .5305\ G_{n-1} + 766{,}383{,}700$ cu. ft. (L)

$E'_n = .4129\ F_{n-1}$

$F'_n = .4085\ F'_{n-2} + .3945\ F_{n-1} + 1{,}496{,}222{,}000$ cu. ft. (M)

$G'_n = .0176\ F_{n-1} + .2333\ G_{n-1}$

TABLE 5.

For the end of the flood, obtained by substituting the actual volumes for the percentages of Table 4.

A_n = 11,957.7 million cu. ft. (M)
B_n = 10,166.7 million cu. ft. (A'_{n-1}) + 2,398.8 million cu. ft. (M)
C_n = 138.1 million cu. ft. (A_{n-1}) + 5,252.7 million cu. ft. (B'_{n-1})
D_n = 835.2 million cu. ft. (B'_{n-1}) + 4,007.3 million cu. ft. (C'_{n-1})
E_n = 3,515.6 million cu. ft. (B'_{n-1})
F_n = 491.6 million cu. ft. (B'_{n-1}) + 3,116.3 million cu. ft. (E'_{n-1}) + 3,766.6 million cu. ft. (F'_{n-1}) + 128.8 million cu. ft. (G'_{n-1})
G_n = 50.6 million cu. ft. (C'_{n-1}) + 177.0 million cu. ft. (D'_{n-1}) + 74.8 million cu. ft. (G'_{n-1})

29 For the end of the ebb

A'_n = 8,644.8 million cu. ft. (B_{n-1}) + 766.2 million cu. ft. (C_{n-1}) + 780.5 million cu. ft. (E_{n-1}) + 113.3 million cu. ft. (K)
B'_n = 4,624.7 million cu. ft. (C_{n-1}) + 1,605.9 million cu. ft. (D_{n-1}) + 2,735.1 million cu. ft. (E_{n-1}) + 1,338 8 million cu. ft. (F_{n-1}) + 1,676.9 million cu. ft. (K)
C'_n = 1,332.9 million cu. ft (C'_{n-2}) + 749.8 million cu. ft. (D'_{n-2}) + 3,236.7 million cu. ft. (D_{n-1}) + 71.4 million cu. ft. (G_{n-1})
D'_n = 3,915.7 million cu. ft. (D'_{n-2}) + 160.4 million cu. ft. (G_{n-1}) + 766.4 million cu. ft. (L)
E'_n = 3,116.3 million cu. ft (F_{n-1})
F'_n = 3,091 9 million cu. ft. (F'_{n-2}) + 2,980.8 million cu. ft. (F_{n-1}) + 1,496.2 million cu. ft. (M)
G'_n = 133.1 million cu. ft. (F_{n-1}) + 70.5 million cu. ft. (G_{n-1})

TABLE 6.

In percentages of the volume in each area in question the formulæ become:

For the end of the flood

A_n = 100% (M)
B_n = 80.91% (A'_{n-1}) + 19.11% (M)
C_n = 2.57% (A'_{n-1}) + 97.43% (B'_{n-1})
D_n = 17.24% (B'_{n-1}) + 82.76% (C'_{n-1})
E_n = 100% (B'_{n-1})
F_n = 6.55% (B'_{n-1}) + 41.53% (E'_{n-1}) + 50.20% (F'_{n-1}) + 1.72% (G'_{n-1})
G_n = 24.75% (G'_{n-1}) + 16.71% (C'_{n-1}) + 58.54% (D'_{n-1})

For the end of the ebb

A'_n = 83.89% (B_{n-1}) + 7.45% (C_{n-1}) + 7.56% (E_{n-1}) + 1.10% (K)
B'_n = 38.60% (C_{n-1}) + 13.40% (D_{n-1}) + 22.83% (E_{n-1}) + 11.17% (F_{n-1}) + 14.40% (K)
C'_n = 24.72% (C'_{n-2}) + 13.92% (D'_{n-2}) + 60.04% (D_{n-1}) + 1.32% (G_{n-1})
D'_n = 80.86% (D'_{n-2}) + 3.31% (G_{n-1}) + 15.83% (L)
E'_n = 100% (F_{n-1})
F'_n = 40.85% (F'_{n-2}) + 39.38% (F_{n-1}) + 19.77% (M)
G'_n = 65.38% (F_{n-1}) + 34.62% (G_{n-1})

Capacity of the Harbor Waters to Receive Sewage Without Undue Pollution.

From the equations given above the composition of the waters of each of the parts of the harbor can be calculated for any tidal period. Jamaica Bay is entirely independent, and its capacity is discussed separately in the special report submitted on the drainage area tributary to it. The Lower Bay to the west of the channel leading to the Narrows is also independent. Its waters are changed with each tide, and the circulation between the Kill von Kull and the Arthur Kill is but slight.

It may be assumed with safety that the west part of the Lower Bay has sufficient capacity to receive and care for all of the sewage from its drainage area. Our data is insufficient to show with certainty the conditions in the Arthur Kill, but from the tidal conditions it is evident that its capacity is not large and it is now receiving over 16,000,000 gallons per day from the New Jersey sewer systems discharging into it. Further discussion of this capacity will be found in Chapter IV., in the report on the Borough of Richmond.

Returning to the other portions of the harbor discussed in the preceding pages it may be stated that their only source of supply of unpolluted water is from the sea and Sound—and that the oxygen of this supply is augmented to any appreciable degree only through reaeration while in the harbor.

Much misapprehension exists as to the extent to which the harbor waters renew their oxygen from this source and it is, therefore, deemed advisable to go into this subject somewhat extensively. The subject has been under investigation for some years by Prof. Phelps, and his conclusions are embodied in the following chapters. For present purposes it is sufficient to state that under the most favorable assumptions the absorption of oxygen from the air (reaeration) in the waters of New York Harbor will give an increase of 1.9 per cent. of the saturation value in 24 hours or of 0.475 per cent, in a six-hour period.

Our studies have shown that the volume of pure sea water which enters the harbor limits between the Narrows and Throgs Neck each twelve hours is 29,135 million gallons, which contain under summer conditions about 1,946,218 pounds of dissolved oxygen. If this oxygen were to be reduced to 70 per cent. of the saturation value by sewage reduction, 583,865 pounds would be so used in the twelve hours. The total volume of water in New York Harbor within the limits named is 251,418 million gallons; if this is reduced to 70 per cent. it will in itself absorb in twelve hours 0.95 per cent. of its saturation value or 159,550 pounds. This with the amount available from the pure sea water entering gives a total of 743,415 pounds of oxygen. This assuming a sewerage production of 100 gallons per capita per day would care for a population of 7.4 millions.

The above figures show great possibilities could all of the sewage discharge be concentrated at the two entrances, and there thoroughly

diffused through the channels. Under existing conditions of discharge but little advantage is taken of them since only a small proportion of the pure water ever reaches the shores of Manhattan, as is shown by the equations of tables 4, 5 and 6. These equations indicate, however, that the nearer the sewage is carried to the harbor entrances, the greater will be the amount that can be cared for without undue pollution of the waters.

The existing population in New York and vicinity, whose sewage is emptied into the various areas is shown in the following table, which has been compiled from the best available sources: the sewage discharge is computed at 100 gallons per capita per day.

31 TABLE 7.

Locality.	Estimated population.	Estimated sewage for twenty-four hours in million cubic feet.	Estimated sewage for six hours in million cubic feet.
A—Lower Bay	50,195	.7	.17
B—Upper Bay	367,816	4.9	1.23*
C—Hudson River, Battery to Ninety-sixth street	755,992	10.1	2.53
D—Hudson River, Ninety-sixth street to Spuyten Duyvil	165,260	2.2	.55
E—East River, Battery to Hell Gate	2,212,295	29.6	7.40
F—East River, Hell Gate to Throgs Neck	246,601	3.3	.82
G—Harlem River	651,098	8.7	2.18
Total	4,449,257		

* To this will be added the sewage from the Passaic Valley System, when completed, 4.28 million cubic feet, which, when discharged, will be freed from 20 per cent. of its putrescible organic contents.

If we assume that the total oxygen of the waters is not to be reduced more than 30 per cent., there will be 20.4 pounds of oxygen available for each million gallons of pure water contained in each area during any tidal period. Reaeration in 12 hours would increase the oxygen contents by 0.6 pounds per million gallons of the total volume of water. This would make the following additional amount of oxygen available for each area for each six-hour period.

TABLE 8.

A = 11,131.2 million cubic feet = 83,261.4 million gallons = 49,956 pounds oxygen.
B = 12,273.7 million cubic feet = 91,807.3 million gallons = 55,084 pounds oxygen.
C = 5,390.8 million cubic feet = 40,323.2 million gallons = 24,194 pounds oxygen.
D = 4,842.5 million cubic feet = 36,221.9 million gallons = 21,733 pounds oxygen.
E = 3,315.9 million cubic feet = 24,802.9 million gallons = 14,882 pounds oxygen.
F = 7,536.1 million cubic feet = 56,370.0 million gallons = 33,822 pounds oxygen.
G = 253.0 million cubic feet = 1,892.4 million gallons = 1,135 pounds oxygen.

Were it not for the circulation of the waters back and forth between the different areas it would be a simple matter to determine the amount of sewage the waters of each area could care for without undue pollution, or the average pollution of these waters under exist-

ing conditions with the sewage thoroughly diffused through them. Under conditions as they exist, however, it is necessary to compute the dilution through a number of successive tides.

Using the formulæ in Table 4 and the figures for sewage in Table 7, the amount of sewage received in each area from the various sources was computed. To this was added the additional amount of sewage from the various waters, computed by means of the
32 same formulæ, through successive tides. With the amount of sewage thus obtained the percentage of dilution for each tide was obtained. The change in the dilution ratio for each area for successive tides of the same character was found to be a decreasing one. These ratios were then plotted and the points joined by a regular curve. From these curves the ultimate dilution ratio was then taken. These ratios are given in Table 9.

In considering these dilution ratios, it must be remembered that a safe ratio for dilution for one waterway cannot be assumed as safe for another. It is evident that if the flow of the waterway is in one direction only, the pollution added at a given point affects only the waters down stream from that point, whereas in a tidal stream, the polluted waters may return past the original point of pollution many times before being finally removed. Again for safety, this ratio must be a function of the rate of reaeration of the waterway, or of the time before its waters are further purified by an additional supply of unpolluted water. Other considerations such as the uses to which the polluted waters are put and the character of the territory through which they flow have also weight in determining the safe ratio.

As shown by studies of Brooklyn sewage, for reduction to a stable form each million gallons of sewage will require the consumption of between 1,500 and 6,000 pounds of oxygen under summer conditions, of which from 500 to 2,000 pounds is taken up in twelve hours. If we assume an average oxygen consumption of 2,000 pounds per million gallons of sewage and an increase of oxygen supply of .475 per cent. of saturation value for reaeration in six hours, the oxygen contents may be calculated; these values are given in Table 9. They are approximate and for summer conditions only.

TABLE 9.

Area.	Dilution ratio.	Per cent. of oxygen present. Without reaeration.	With reaeration.
	Flood.		
A	.....	100	100
B	1 in 120	75.0	75.5
C	1 in 65	54.0	54.4
D	1 in 58	48.4	48.9
E	1 in 63	52.5	53.0
F	1 in 100	70.1	70.6
G	1 in 50	39.4*	40.6
	Ebb.		
A'	1 in 100	70.1	70.6
B'	1 in 65	54.0	54.4
C'	1 in 57	47.5	47.9
D'	1 in 55	45.6*	46.0
E'	1 in 100	70.1	70.6
F'	1 in 150	80.0	80.5
G'	1 in 60	50.1	50.6

* Largely result of pollution of Hudson above limits of Greater New York.

33 Calculations were then made on the assumption that all the sewage discharged into the Hudson within the limits of Greater New York and into the Harlem as well as that discharged into the Upper Bay from the Passaic Valley sewer is reduced two-thirds by purification. These computations were made in the same manner as the foregoing and the results are given in the table below, which are also approximate and for summer conditions.

TABLE 10.

Area.	Dilution ratio.	Per cent. of oxygen present. Without reaeration.	With reaeration.
	Flood.		
A	.....	100	100
B	1 in 200	85.0	85.5
C	1 in 80	62.6	63.0
D	1 in 80	62.6	63.0
E	1 in 75	60.0	60.5
F	1 in 120	75.0	75.5
G	1 in 70	57.2*	57.7
	Ebb.		
A'	1 in 190	84.3	84.8
B'	1 in 77	61.1	61.6
C'	1 in 80	62.6	63.0
D'	1 in 62	51.7*	52.2
E'	1 in 120	75.0	75.5
F'	1 in 180	83.4	83.9
G'	1 in 90	66.7	67.2

* Result of pollution of Hudson River above limits of Greater New York.

Computations were next made to show what would result if the discharge of sewage were made at the two entrances of the harbor, at the Narrows and near Throgs Neck.

Assuming that the sewage discharged into areas B, C, D, ½ E and ½ G is discharged at the Narrows, and that from areas ½ E, F and ½ G at Throgs Neck, computations were made by means of the same formulæ and in the same manner as before. The results for summer conditions are shown in the following table:

34 TABLE 11.

Area.	Dilution ratio.	Per cent. of oxygen present. Without reaeration.	With reaeration.
	Flood.		
A	.....	100	100
B	1 in 210	85.8	86.3
C	1 in 200	85.0	85.5
D	1 in 140	78.6	79.1
E	1 in 240	87.5	88.0
F	1 in 220	86.4	86.9
G	1 in 90	66.7*	67.2
	Ebb.		
A'	1 in 210	85.8	86.3
B'	1 in 240	87.5	88.0
C'	1 in 130	77.1	77.5
D'	1 in 72	58.4*	58.9
E'	1 in 220	86.4	86.9
F'	1 in 240	87.5	88.0
G'	1 in 150	80.0	80.4

* Result of pollution of Hudson River above limits of Greater New York.

Table 11 shows the results of the concentration of the discharge of the sewage of the entire drainage area of the harbor at the Narrows and at Throgs Neck, with the existing population. Referring to the computations of available oxygen given on page 34, about two-thirds of the amount would be available at the Narrows and one-third at Throgs Neck.

35 Chapter II.

The Absorption of Atmospheric Oxygen by Water.

Quiescent Water.

Discussion of the Problem.

Atmospheric oxygen is soluble to a limited extent in water, the maximum amount which can thus be dissolved under any given set of conditions being known as the "saturation value." Under the fairly uniform conditions of pressure with which we have to deal the saturation value is chiefly a function of temperature. Like other gases oxygen is practically insoluble in boiling water and the

solubility increases progressively with decreasing temperature. The composition of the water has also some influence, salt water dissolving less oxygen than fresh water under the same conditions. We may confine our attention for the present to the behavior of oxygen in water, although the laws of diffusion and solubility which we shall consider are of general application to other gases such as nitrogen and carbon dioxide.

If a given column of water, containing less oxygen in solution than it can take up under the existing conditions, is exposed to the atmosphere, it begins to absorb oxygen. This process proceeds at a decreasing rate, governed by certain fixed laws until a condition of saturation is reached. The rate of this absorption has been the subject of several investigations, the latest and best known of which were made by Adeney, (1) in connection with his investigations of the pollution of waters by sewage. Adeney exposed long tubes of partially deaerated water, i. e., water containing in solution less oxygen than would be required to saturate it, to the atmosphere. After various intervals of time and from various depths specimens of the water were removed for analysis. In this way, valuable information was obtained as to the amount of oxygen, and other gases, absorbed by a column of water under the conditions of the experiment. Adeney presented his full experimental results without any attempt at generalization or any expression of the underlying physical law. His results, valuable as they are, are applicable to the practical case only when that case happens to coincide in all the variable factors, with the experimental condition. What these variable factors are was not shown by this work and serious misuse of Adeney's figures has been made by others, as will be pointed out later, through overlooking these obvious facts, and applying the figures in a way which finds no justification in the original paper. The writer some years ago undertook an investigation of this same question at the Sewage Experiment Station of the Massachusetts Institute of Technology, the results of which are presented here for the first time. (2) It was apparent at the outset that the fundamental physical law of absorption of atmospheric oxygen by water was so complex that a satisfactory generalization could only
36 be arrived at through a mathematical study of the law itself, coupled with an experimental investigation to determine the constants involved. This experimental work must be so planned as to eliminate successively the various variable factors developed in the mathematical study, and thus fix the constants involved from all conditions. A check upon both the mathematical and the experimental work would be had if satisfactory constants could be obtained. Because of the wide interest and discussion which Adeney's results have created among investigators of pollution problems and because

(1) Fifth report Royal Commission on Sewage Disposal. Appen. VI., 1908, p. 54. Trans-Royal Dublin Soc., 1905, p. 161. Phil. Mag., Mar., 1905.

(2) The experimental work involved in these investigations was carried out by Mr. Frances E. Daniels, to whose skill in technique and in the designing and making of the special apparatus required, the successful outcome is in a large measure due.

both the theoretical and the experimental portions of the writer's studies have led to quite different conclusions, it will be necessary to describe our early methods and results and also certain experiments undertaken by the writer later to explain the apparent discrepancies.

Theoretical and Experimental.

The physical theory of absorption will first be briefly stated. In order that there shall be absorption it is always presupposed that the water contains less oxygen than is required to saturate it. Let it be assumed, as an initial condition, that such a body of water, having a uniform oxygen content throughout its depth, be exposed on its surface to the atmosphere. At once the surface begins to absorb oxygen at a definite rate. This rate is dependent upon the relation between the initial oxygen concentration and the saturation concentration. In other words, water at 80 per cent. of saturation, i. e., containing 80 per cent. as much oxygen as it can contain, will start to absorb twice as rapidly as will water at 90 per cent. of saturation. This is the well-known law of rate of solution and is the first physical principle involved in this discussion. The absorption of oxygen would therefore come to a speedy end through saturation of the surface layer, were it not for a second and more important principle known as the law of hydro-diffusion. This principle shows that any dissolved substance existing in different concentrations at different parts of the solution tends to diffuse toward the point of low concentration. In its full quantitative expression the lay of hydro-diffusion, known from its discoverer (3) as Fick's law, states that the rate of diffusion of any dissolved substance through the liquid and between two proximate points is proportional to the difference in concentration of the substance at those two points. The proportionality is designated by a constant known as the diffusion coefficient. A consideration of this law will show that after the absorption and the diffusion have been going on for any definite time the curve of concentration within the liquid will start at practically the saturation value at the very surface and run down to pracically zero at some point within. This zero point will move deeper and deeper into the liquid with increasing time. The mathematical form of this curve can be determined in terms of the time, the depth, and the diffusion coefficient. The area under the curve taken between suitable limits representing the total depth of water gives the total amount of dissolved oxygen contained in the tube after any stated time interval. This area is obtained in the usual way, by integration between limits. The final result is expressed also in terms of time, depth, and the diffusion coefficient. The final working formula is:*

(3) Nernst, Theoretische Chemie., 2d German Ed., p. 156.

* The full mathematical derivation of this formula is given in the appendix.

37

$$D = 100 - \left[\left(1 - \frac{B}{100}\right) \cdot 81.06 \cdot \left(0.779^{2} + \frac{0.125^{2}}{9} + \frac{0.0025^{2}}{25} - \cdots\right) \right]$$

B Initial value of dissolved oxygen.
D Final value of dissolved oxygen.
K A constant for each experiment $= \frac{\pi^2 at}{L^2}$
t Time in hours.
L Depth in centimeters.
a Diffusion co-efficient.

All oxygen values are expressed in the unit, "per cent. of saturation." This equation permits the evaluation of the coefficient, "a," from the determinations of the total amount of dissolved oxygen in a sample before and after exposure to the air, the time of exposure and length of tube being noted. This procedure therefore greatly facilitates the experimental determinations of the coefficient. In terms of the units that have been employed, "a" is the amount of oxygen expressed in per cent. of saturation, which would pass through a plane one square centimetre in area in one hour if the concentration gradient at that point were 1 per cent. of saturation per linear centimetre. After the value of "a" is known this equation also permits a calculation of the actual rate of reaeration under any given conditions of time, depth, and initial oxygen content. In determining the values of the coefficient it was found necessary to develop a special method of determining dissolved oxygen in water, and one was finally devised that is about ten times as sensitive as the present standard Winkler Method.* Special apparatus and refined technique were necessary to secure successful results. One of the greatest sources of error in tests of this kind lies in changes of temperature. Even minute changes will cause a circulation within the tube which will vitiate the results. Therefore, the work was done throughout in a carefully regulated water bath in which the temperature was held practically constant during the test.

Determinations of the coefficient were made with tubes of varying lengths and under exposures of varying periods of time, to test the two variables of the formula. The results were reasonably concordant, and when plotted against their corresponding temperatures, showed a distinct relation to the temperature. From a smooth curve representing the best average values at all points the following summary of values of the coefficient over the temperature range investigated were obtained.

* This method is described in the appendix.

Values of Diffusion Coefficient of Oxygen in Distilled Water at Various Temperatures.

Temperature C.	"a."
5	0.65
10	0.75
15	1.00
20	1.42
25	2.43

38 Results.

Having utilized the formula in the experimental determination of the coefficient, we may now reverse the process and apply our calculations to the practical problem of absorption. Since the law governing the course of this absorption has been formulated, and is seen to contain factors for the variable conditions to be met with, such application may be made with assurance of reasonable accuracy. Consider, first, conditions in quiescent fresh water. Other conditions will be treated later. It is obvious that the rate of absorption into a given volume of water must be a function of the depth of water. One million gallons of water exposed in a one-foot layer would absorb oxygen faster than it would if exposed in a five-foot layer. The equation shows in what way the depth is related to the problem. A second factor is the time allowed for absorption. This requires no discussion. A third factor is the initial condition. The more nearly saturated the body of water, the slower will be the rate of absorption. This principle of rate of solution has already been discussed.

The equation has been solved for a number of sets of conditions in order to illustrate its application. The actual solution is a matter of no small difficulty. It is necessary to employ forty terms of the converging series in the case of the smaller "K" values to secure accuracy. For purposes of greater practical use the quantities are given in pounds of oxygen per million gallons of water as well as in the original form, per cent. of saturation. The latter form of expression is the more useful to illustrate the magnitude of the reaeration effect. The former will be of use in our calculations of the capacity of the water to oxidize sewage. The three variables of depth, time and initial concentration are considered separately

89

TABLE 12.

Amount of Oxygen Absorbed from the Atmosphere by a Quiescent Body of Fresh Water at 20° C. During Stated Periods of Time, at Stated Depths and with Stated Initial Concentration, Expressed in per Cent. of Saturation.

Initial concentration, per cent. saturation.	Time in hours.					
	1	6	10	12	20	24
Depth Five Feet.						
0	0.83	2.17	2.80	3.05	3.93	4.45
10	0.74	1.95	2.52	2.74	3.53	4.00
30	0.58	1.52	1.96	2.14	2.74	3.12
50	0.42	1.08	1.40	1.52	1.96	2.22
70	0.25	0.65	0.84	0.92	1.18	1.34
90	0.08	0.22	0.28	0.31	0.39	0.45
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Ten Feet.						
0	0.30	1.05	1.45	1.53	1.97	2.17
10	0.27	0.94	1.30	1.38	1.77	1.95
30	0.21	0.74	1.02	1.07	1.38	1.52
50	0.15	0.52	0.72	0.76	0.98	1.08
70	0.09	0.32	0.44	0.46	0.59	0.65
90	0.03	0.11	0.18	0.15	0.20	0.22
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Fifteen Feet.						
0	0.15	0.60	0.87	0.96	1.30	1.45
10	0.14	0.54	0.78	0.86	1.17	1.30
30	0.10	0.42	0.61	0.67	0.91	1.02
50	0.08	0.30	0.44	0.48	0.65	0.72
70	0.04	0.18	0.26	0.29	0.39	0.44
90	0.02	0.06	0.09	0.10	0.13	0.15
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Twenty Feet.						
0	0.10	0.40	0.57	0.67	0.93	1.05
10	0.09	0.36	0.51	0.60	0.84	0.94
30	0.07	0.28	0.40	0.47	0.65	0.74
50	0.05	0.20	0.28	0.34	0.46	0.52
70	0.03	0.12	0.17	0.20	0.28	0.32
90	0.01	0.04	0.06	0.07	0.09	0.11
100	0.00	0.00	0.00	0.00	0.00	0.00

Exhibit 136-p. 41

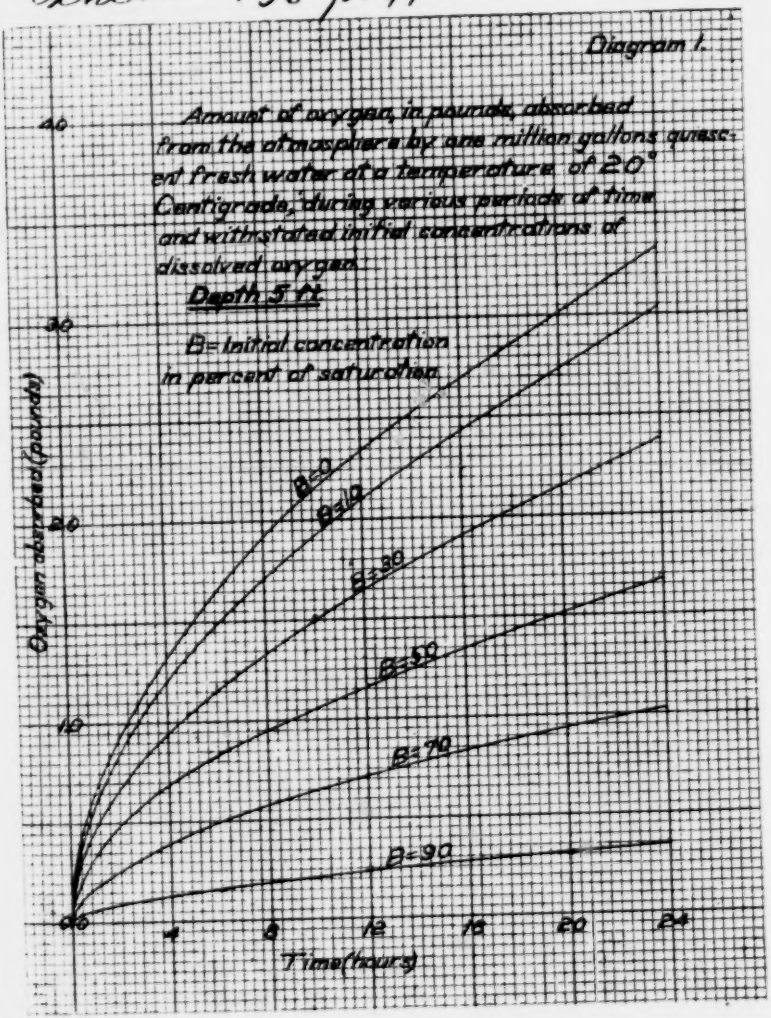


Exhibit 136-p. 42

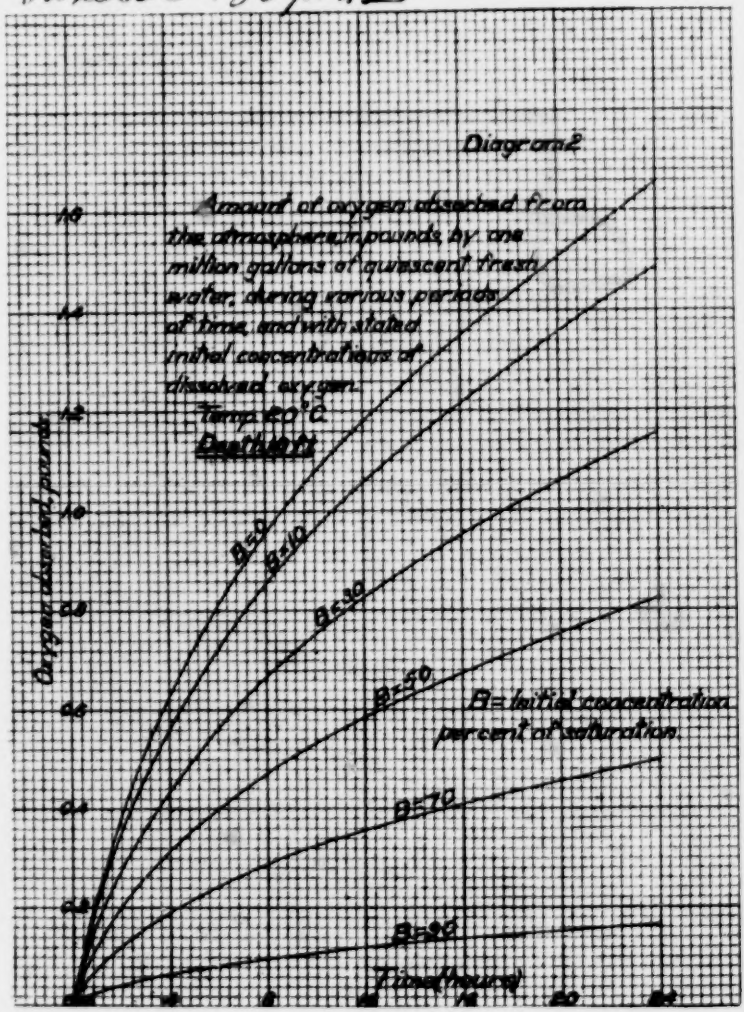


Exhibit 136-p. 43

Diagram 9.

Amount of oxygen, in pounds, absorbed from the atmosphere by one million gallons of quiescent fresh water during various periods of time and with stated initial concentrations of dissolved oxygen.

Temp. 20°C.

Depth 15 ft.

B=Initial concentration in percent of saturation

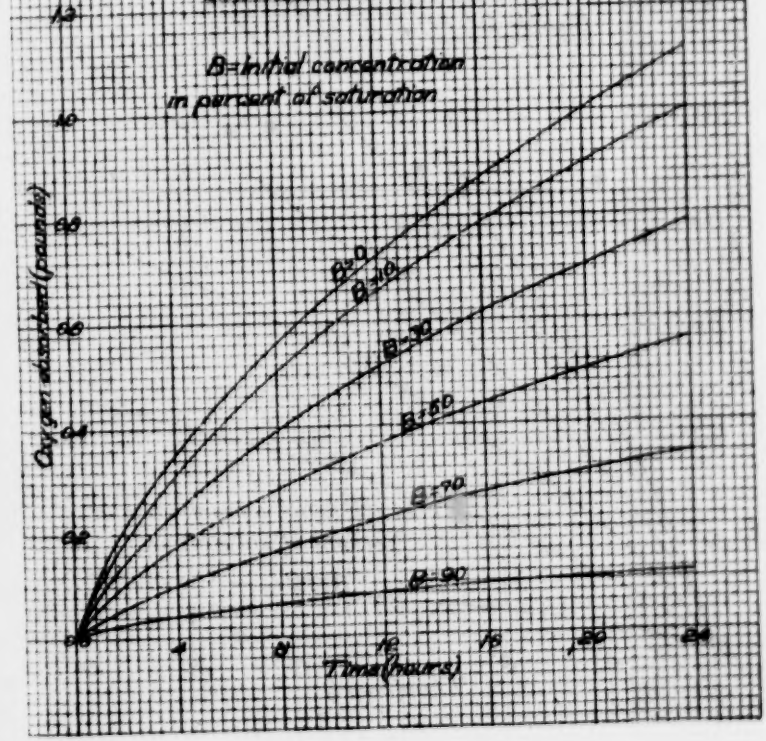
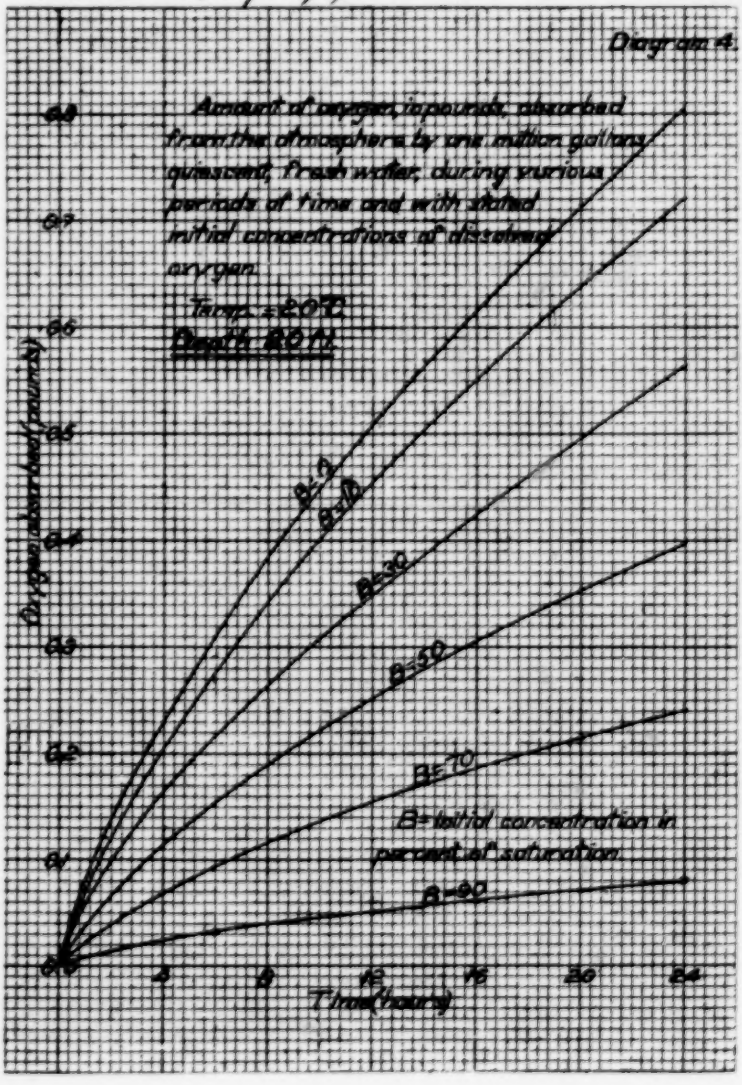


Exhibit 136-p. 44



40 TABLE 13.

Amount of Oxygen Absorbed from the Atmosphere by a Quiescent Body of Fresh Water at 20° C. During Stated Periods of Time, at Stated Depths and with Stated Initial Concentration, Expressed in Pounds per Million Gallons.

Initial concentration, per cent. saturation.	Time in hours.					
	1	6	10	12	20	24
Depth Five Feet.						
0	0.636	1.66	2.14	2.34	3.00	3.41
10	0.566	1.49	1.93	2.10	2.70	3.06
30	0.444	1.16	1.50	1.64	2.09	2.39
50	0.322	0.827	1.07	1.16	1.50	1.68
70	0.193	0.497	0.643	0.704	0.904	1.03
90	0.064	0.166	0.214	0.234	0.300	0.341
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Ten Feet.						
0	0.229	0.804	1.11	1.17	1.51	1.66
10	0.207	0.720	0.995	1.06	1.36	1.49
30	0.161	0.596	0.781	0.820	1.06	1.16
50	0.115	0.398	0.551	0.581	0.750	0.827
70	0.069	0.245	0.331	0.352	0.452	0.497
90	0.023	0.080	0.111	0.12	0.151	0.166
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Fifteen Feet.						
0	0.115	0.459	0.666	0.735	0.996	1.11
10	0.107	0.413	0.597	0.658	0.896	0.995
30	0.077	0.322	0.467	0.513	0.696	0.781
50	0.061	0.230	0.337	0.367	0.497	0.551
70	0.031	0.138	0.199	0.222	0.299	0.337
90	0.012	0.046	0.067	0.074	0.100	0.111
100	0.00	0.00	0.00	0.00	0.00	0.00
Depth Twenty Feet.						
0	0.077	0.306	0.436	0.513	0.712	0.804
10	0.069	0.276	0.390	0.459	0.643	0.721
30	0.054	0.214	0.306	0.360	0.497	0.566
50	0.038	0.153	0.214	0.260	0.352	0.398
70	0.023	0.092	0.130	0.153	0.214	0.245
90	0.008	0.031	0.044	0.051	0.071	0.080
100	0.00	0.00	0.00	0.00	0.00	0.00

(Here follow diagrams 1, 2, 3, and 4, marked pages 41 to 44, Complainants' Exhibit 136.)

45 The results of the calculations are given in Tables 12 (per cent. of saturation) and 13 (pounds per million gallons). The same information is given graphically in Diagrams 1 to 4.

It is seen that, in quiescent fresh water at least, the rate of absorption is so low that reaeration in this case cannot play an important part in self-purification. A ten-foot column of water, for example, starting at 50 per cent. of saturation, would absorb only enough oxygen in 24 hours to bring its average oxygen content up to 51 per cent. The dependence of the rate of absorption upon the initial condition is also clearly shown. For example, the amount of oxygen which will be absorbed from the atmosphere in one hour by a ten-foot column of water containing only 10 per cent. of the saturation value of oxygen is nine times as great as is the case with an initial value of 90 per cent. It should also be noted that the rate of reaeration is rapid at first and diminishes quickly with time. This rapid initial absorption involves an initial condition of uniform mixing in the column of water under consideration. In practice such a condition seldom obtains, and it is in general the absorption occurring after the first or later hours that are of practical value. In a quiescent body of water the average hourly rate after 24 hours or even longer periods and not the rate during the first hours after uniform mixing, is the proper value for use. This point, which distinguishes the condition of quiescent water from that of water having vertical movements, will be referred to again in the discussion of the effect of winds and boats.

Application.

A serious misuse has been made of the results reported by Adeney in that his rates of absorption into fully deaerated water of comparatively shallow depths have been used to determine the rate of reaeration of a natural body of water which in the nature of things would have much greater depth and would never be permitted to approach a condition of complete deaeration. For example, a recent writer has stated (4) "In tidal salt water the results may be, on the whole, better, for while half fresh water and half salt water will contain less oxygen when saturated, its powers of reaeration are almost double fresh water. At 64° F. it will draw from the air 0.62 of a pound per hour per million gallons of its volume, and at increasing rate as the salt increases.

"The basin of New York harbor inside the Narrows, and below 140th Street on the Hudson, and Hell Gate on the East River, leaving out Kill von Kull, contains, at mean tide, 203,467 million gallons. At the known rate of absorption of 0.62 pounds per million gallons, its hourly reaeration amounts to 126,150 pounds, enough to destroy the organic matter in the sewage of sixty million people, at 100 gallons per head per day, provided the sewage is

(4) Edlow W. Harrison, Proc. 35th Ann. Meeting, N. J. Sanitary Assn., 1909, p. 77.

properly delivered to the water, without reducing the normal oxygen."

Passing by for the moment the reference to the effect of dissolved salts in water upon the rate of reaeration, a question which will be fully discussed later, it must be pointed out here that the depth and condition of aeration of the water, essential factors in the rate of reaeration, have been ignored in the above calculations. Any statement of the magnitude of absorption or reaeration must, to
46 have any weight at all, be limited by considerations of the three fundamental variables of the problem—time, depth and initial condition.

It is this same point which is of such predominating influence in running streams. A stream five feet deep, which is completely mixed but once in an hour, will absorb oxygen three times as fast as would a body of water which is mixed but once in twelve hours. If our tables showed the facts for 15-minute intervals after mixing, a condition more nearly that of even sluggish streams, the effect would be still more striking.

Salt Water Conditions.

Thus far this discussion has referred to fresh water. Actual data for the determination of the diffusion coefficient in sea water are lacking. The known facts concerning the physical properties of solutions would indicate a slower rate of absorption. On the one hand the solubility is less, so that smaller concentration gradients and consequently less diffusion would necessarily follow even with the same value of the diffusion coefficient, "*a*." Our diffusion law refers to "per cent. of saturation," so that with the same value of "*a*" the absorption, expressed in this unit, is the same. If the saturation value be diminished by any cause, the actual amount of oxygen absorbed is correspondingly decreased. In the second place diffusion coefficients in general are decidedly reduced by increased viscosity of the fluid, so that, judging by analogy, the value of "*a*" in salt water would be decreased. All told, the rate of diffusion into salt water is certainly not greater and is probably much less than into fresh water. These statements are apparently confirmed by certain experiments of Adeney's, in which tubes of fresh and salt water were exposed under similar experimental conditions.

The "Streaming Effect."

On the other hand, under certain conditions, salt water apparently dissolves atmospheric oxygen more rapidly than fresh. Adeney and others have noted that, while in fresh water there is a tendency toward accumulation of the oxygen near the surface (as would be indicated by the mathematical formula), in the case of salt water the oxygen tended to distribute more evenly through the tube. This phenomenon has been called the "streaming effect" and was first noted by Hufner. (5) Adeney found it always present when salt

(5) Ann. Phys. Chem. LX., 1897, 134.

water was used but most markedly so when a jet of air was introduced just below the surface of the water. In the case of fresh water there was no such effect. There was no circulation of the water produced mechanically by the jet. Adeney found further that the so-called "streaming effect" was due to some unknown property of the air and that that property was lost after passing once through water. So that if the same air was passed successively through the top layer of two tubes of water a streaming would take place in the first, but only slightly or not at all in the second. It was concluded that this effect was due to dust particles in the air acting possibly as electrical condensation points, or to some other electrical property of the air, such as ionization, which property way produced a downward streaming of the oxygen mole-
47 the ionized salts of the water this electrical property in some way produced a downward streaming of the oxygen molecules. Adeney attempted to show that there was no actual circulation of the liquid, but his test was not a conclusive one in that it was not sufficiently sensitive.

This phenomenon assumes importance in view of the results that have now been described. This "streaming effect" of the oxygen amounts virtually to a continuous mixing of the water so that the oxygen values resulting would correspond with those initial rates of absorption already referred to in the case of running streams. It is upon this basis of very rapid absorption, as determined quantitatively by Adeney, that Mr. Edlow Harrison's estimate of 0.62 pounds per hour per million gallons was based.

The logical deduction from Adeney's investigation was that, owing to the peculiar streaming effect, salt water would reaerate itself at a rate many times greater than that observed in fresh water.

The writer became interested in the great practical importance of this aspect of the matter and during the past year undertook an investigation of the streaming effect. It was decided to employ a most sensitive detector of circulating currents, since the evidence on this point was not conclusive. Adeney had used a crystal of bichromate dropped into his tube. Under these conditions a thin layer of a very heavy saturated solution forms on the bottom, and the contents of the tube would have to be stirred quite vigorously to remove it. Our test for circulation was the addition of a solution of methylene blue in the same water as that under investigation. So delicate was this test that the addition of 1 per cent. of methylene blue to sea water gave the mixture a density sufficiently to cause it at once to descend to the bottom of a tube of the same water. This colored mixture was therefore diluted until it would just float on the surface of the tube. The slightest tendency toward circulation was made manifest at once by streaks of blue water descending. With tubes of fresh and salt water thus prepared, and others similarly prepared with the indicator water on the bottom, Adeney's experiments were repeated and exactly confirmed. In every case where he obtained streaming there was a visible streaming of the blue color. In the case of fresh water and also of salt water, if

treated with air that had already passed through one tube of water, there was no streaming. It was demonstrated that the streaming of oxygen was only a secondary effect, due to the streaming of the liquid as a whole. Furthermore, the real source of the streaming now became apparent. It was due to the evaporation of the top layer of solution, leaving a slightly denser solution on top which then descended. Within one hour after turning on the air this descent frequently began. No streaming occurs in fresh water, for obvious reasons. Adeney's other results are also clear in the light of these experiments. The property which was washed from the air by passing through the first tube was its dryness. The air became saturated and evaporation no longer took place. A sample of such washed air was used in our experiments, but was first passed through a drying tube. It had regained its streaming properties, more vigorously than ever before. In this experiment the water evaporated from the first tube was collected in the drying bulb and weighed. The increased concentration of the top layer of liquid was then calculated at the instant when streaming began. A solution was then made up of this strength and colored. When placed
48 on the top of the standard salt water it immediately descended to the bottom. In brief, it was shown conclusively that the so-called streaming effect was due entirely to evaporation of water from the surface and the consequent increase in the specific gravity of the top layer of the solution. This layer then descended to the bottom. In practice no such results would be observed, since the upper layers of an estuary are always somewhat fresher than the lower.

Therefore, there is no apparent reason to believe that the reaeration of salt water follows any other laws than those which we have determined mathematically and experimentally for fresh water. In the absence of fuller information on the effect of increased viscosity, upon the diffusion coefficient, it can only be stated that the rate of reaeration of salt water is less than that of fresh, in proportion to the respective solubilities of oxygen in the two waters, and still less, but to an unknown extent, by reason of the greater viscosity and consequent small value of the diffusion coefficient.

TABLE 14.

Average Rate in Pounds per Hour at Which a Quiescent Body of One Million Gallons of Fresh Water in Stated Depths Will Absorb Oxygen from the Atmosphere at 20 Degrees C., at Stated Intervals of Time, After a Condition of Uniform Mixing and With an Initial Concentration of Oxygen of 70 per Cent. of Saturation.

Depth, feet.	Time in hours.					
	1	6	10	12	20	24
5	0.193	0.083	0.064	0.050	0.045	0.043
10	.060	.041	.034	.029	.023	.021
15	.031	.023	.020	.019	.015	.014
20	.023	.015	.013	.013	.011	.010

In summary Table 14 is presented to show the essential facts for use in our further studies. This is compiled from Table 13, the 70 per cent. initial condition alone being considered. Under these conditions the rate of oxygen absorption in pounds per million gallons of water per hour in various depths of water and during various intervals of time are shown. These figures represent our best present knowledge of the absorption of oxygen into quiescent fresh water and are excessive for quiescent sea water.

The figures in Table 13 are made the basis of the plot in Diagram 5. This table and the diagram show the total amount of absorption during stated intervals of time. For the purposes of the calculation which follows it is of advantage to have the same data expressed in average hourly rate over stated intervals, rather than total amount. This form of expression is used in Table 14 and in the plot, Diagram 6. A third form of expression is also needed, namely, rate of absorption after any stated interval, as distinguished from average rate during that interval. This form is used in Diagram 8.

(Here follow diagrams 5, 6 and 8, marked pages 49, 50, and 51, Complainants' Exhibit 136.)

Exhibit 136-f-49

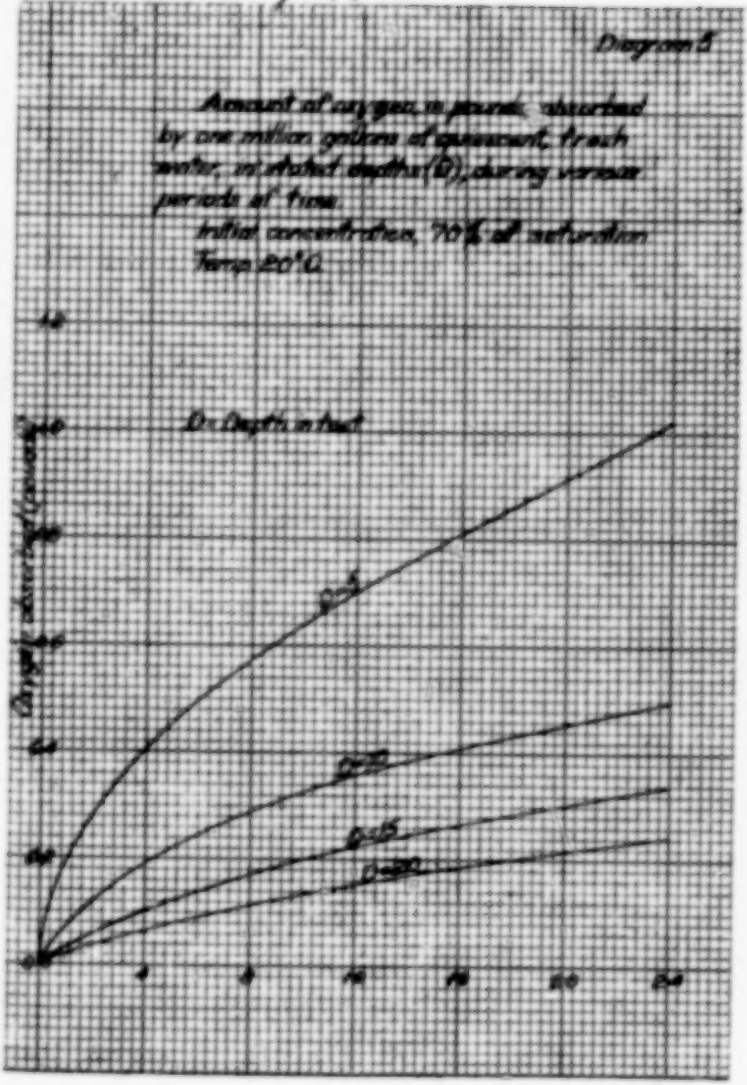
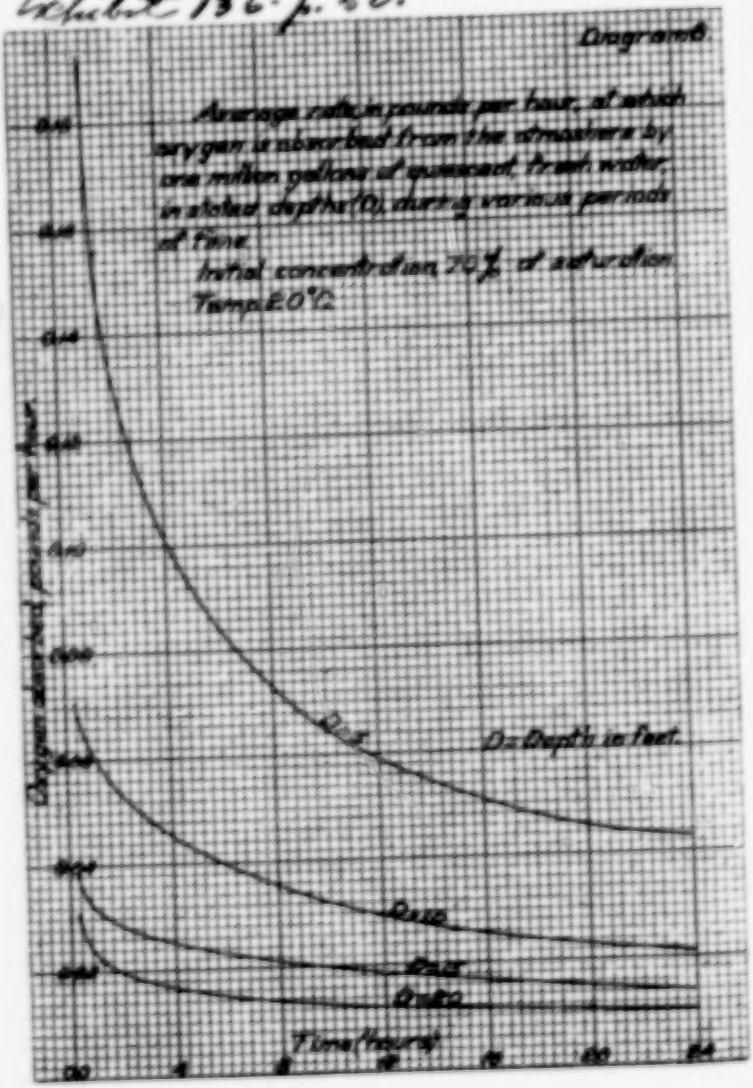
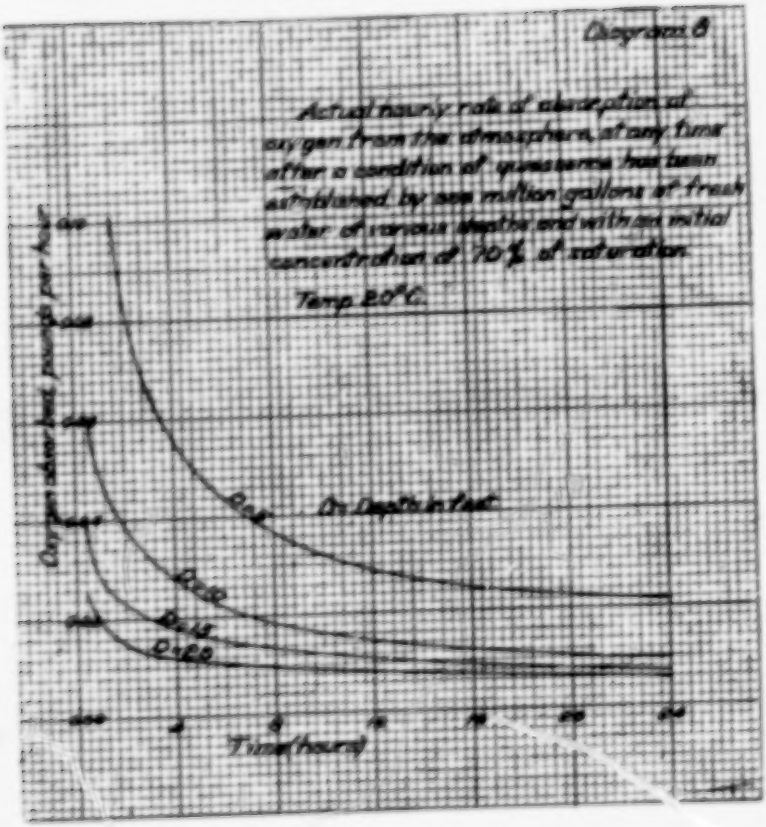


Exhibit 136-p. 50.



Ex. 136-f. 51


Diagram 8
Actual hourly rate of absorption of oxygen from the atmosphere, at any time after a condition of quiescence has been established by one million gallons of fresh water of various depths and with an initial concentration of 70% of saturation.
Temp. 20°C.
Oxygen absorbed, parts per hour
On Depths in Feet
D=8
D=12
D=20
Time (hours)

51 The Effect of Currents and Other Disturbing Factors upon the Rate of Absorption.

The discussion of the rate of absorption has thus far been based upon the assumption that the body of water in question is quiescent. The effect of departures from this assumption must now be considered. This brings up the question of currents, in the broad sense of the word, including eddies, tide and wave action and brief local disturbances such as are caused by passing vessels. More specifically it is the vertical components of these currents only that enter the problem, since these alone induce a vertical circulation. The effect of wind will be first considered.

52 Effect of Wind.

The wind is generally looked upon as an important factor in the aeration of water. The very obvious agitation of the surface, produced by moderate breezes, and the more violent effect of storms, would seem at first glance to lend strength to this view. More careful analysis, however, in the light of the theory of aeration which has been developed makes it possible to test this hypothesis and determine the manner in which wind action must affect aeration, if at all, and approximately at least, the extent of such effect.

Since the fundamental law of aeration is one of diffusion, and fruthermore, since the surface of any body of water is practically saturated at all times, it must be evident that no mere surface action can by itself affect the rate of diffusion. In order to assist the latter there must be an actual mechanical mixing of the water. If such mixing occurs to any given depth by reason of wind action the facts which have been developed thus far permit the following quantitative analysis to be applied.

It has been seen that a body of water starting with a uniform initial concentration of oxygen, B, less than saturation will absorb oxygen, and that by diffusion a concentration gradient is established, from saturation at the surface to the value, B, at some depth within. This process is continuous, but the rate of absorption is a constantly decreasing one. Starting with a condition of uniform mixing the absorption per hour is a maximum at the start and decreases steadily, as is shown in Table No. 3, and more strikingly in Diagram 8.

The immediate effect of wind upon a body of water is to produce wave action. A definite relation exists between the wind velocity, the "fetch" of the wind, i. e., the distance, windward, to the shore, and the size of the wave. The wave in turn sets the water beneath in motion, each particle moving in an elliptical path, whose minor axis, depth, is a function of the wave height. An excellent analysis of the relation between wind velocities, "fetch" and wave height is given by Gaillard (1).

(1) Professional Paper, Engineer Corps, U. S. A., No. 31. Wave Action. D. D. Gaillard, 1904.

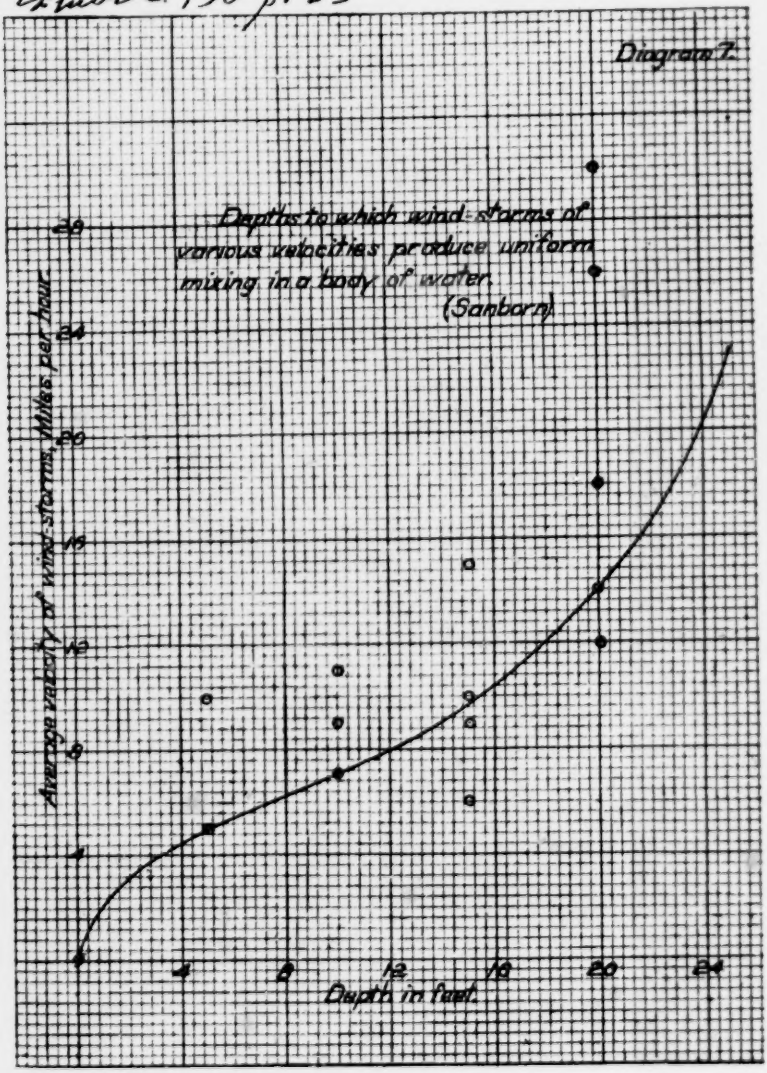
Through the relation between wind action and height of wave, and the secondary relation between height of wave and depth of the movement of the water, it would appear that the velocity of wind would bear some definite relation to the depth of stirring. This relation is not one that can be deduced upon any of the present theories of wave action. In all such theories the principal of "continuity" is a primary assumption. That is, any given plane in the body of water at rest may, owing to wave action, become distorted but must remain continuous and unbroken. This mathematical conception is of course impossible of actual realization and the departure from the ideal condition is in fact the measure of the mixing of the water with which we now have to deal.

The relation between wind velocities and depth of mixing has been recently demonstrated in an ingenious and thorough manner by M. F. Sanborn.* The opportunity for such a study was rather unique. The Charles River Basin had been made by the construction of a dam by which the water within was maintained always at nearly high water mark. A lock in constant service, admitted
54 enough sea water to prevent the complete freshening of the

* Distribution of Sea Water in the Charles River Basin, after Excluding Tidal Water, M. F. Sanborn, Eng. News, 63, 272.

(Here follows diagram 7, marked page 53, Complainants' Exhibit 136.)

Exhibit 136-p. 53



basin and a permanent condition of stratification with regularly increasing salinity with increasing depth has resulted. Disturbances due to wind were therefore easily and quickly recognized by a study of the salinity after wind storms. The condition of uniform mixing thus brought about speedily gave way to the stratified condition normal to the basin and conditions were ready for another test. Sanborn tested the results, all told, of twenty-one storms, ranging in wind velocities from five to thirty miles per hour. The direction of wind was in every case up or down stream with a fetch of one or two miles. The accompanying plot (Diagram 7), is from Sanborn's paper. Stevenson (1) shows that the wave height and consequently the depth of the movement is proportional to the square root of the fetch, so that we may assume that depths approximately twice as great as those found in the Boston experiments will be disturbed by wind storms of corresponding velocities, in New York Harbor. The following values therefore represent the best of our present knowledge and are probably not far from the truth. Since the total effect of wind will be shown to amount only to a minor correction to our figures, approximate values in this case are all that is required. They are for average conditions over the Bay and are excessive for the rivers except during wind storms blowing directly up or down stream.

TABLE 15.

Effect of Wind Producing Vertical Mixing in Water of New York Harbor.

From results of Sanborn upon Charles River (Boston), corrected by observations of Stevenson upon relation of fetch and wave height:

Wind velocity. miles per hour.	Depth of uniform mixing, feet.
5	10
10	31
15	42
20	48

A study of the statistics of the United States Weather Bureau, has shown that during the four summer months, June to September, inclusive, the frequency of wind storms of varying intensities are as follows:

(1) Quoted by Gaillard, p. 67.

TABLE 16.

Frequency of Wind Storms of Stated Velocities.

(Compiled from Weather Bureau Chart.)

Wind velocity, miles per hour.	Average frequency (hours), June to September.
5	2.7
10	8.7
15	32.6
20	240.6

55 Combining these figures with those of Table 15, the frequency with which the water is disturbed to any given depth is determined. These depths and frequencies have been plotted, a smooth curve drawn through the points, and the following values reduced from the curve.

TABLE 17.

Frequency With Which the Waters of New York Harbor Are Uniformly Mixed to Stated Depth by Wind Action.

Depth of mixing (feet).	Frequency (hours), June to September.
12	2.8
20	3.0
30	8.0.
40	24.0

Discussion of the effect of this mixing by wind action will be postponed until the added effect of some other causes have been investigated. The slight breezes which always ruffle the surface have no material effect upon the result. They keep the surface and a few inches below in a state of constant admixture. The result is virtually to decrease the total depth by this amount. Reference to the figures in Table 13 will show that in depths of 20 feet or over a change of one foot in depth has but slight effect upon the rate of absorption.

Effect of Passing Vessels.

The currents produced by the movement of vessels are necessarily considered in a discussion of this kind. Vessels are commonly believed to exert considerable effect upon the aeration of the water. To determine this matter quantitatively the following procedure was adopted. If at any moment of observation, the total number of vessels in motion in the harbor is known, together with their respective speeds, drafts and breadth of beam (at water line), then the area

disturbed per unit of time will be the sum of the products of the respective speeds and beams expressed in common units. For example, a vessel having a beam of 40 feet moving at a speed of ten miles per hour, will disturb a water area of 35,000 square feet per minute. The total area of water being disturbed in this way at any unit of time has been determined by averaging the results of a careful observation and classification of the vessels to be seen at any one time in the Hudson and East Rivers, between the Lackawanna Station, Hoboken, the Navy Yard, and Governor's Island. These observations were made at various hours during the day for a period of two weeks. The most used waters were purposely selected for these determinations in order that maximum value might be obtained. For the same reason the hours of heaviest traffic only were taken and no attempt was made to get night observations. The results of the inspection and the average speeds and dimensions are given in Table 18. In this case as in the case of wave action the sum total of the effect is found to be of minor value, so that approximate accuracy only is required.

56 TABLE 18.

Statistics of Vessels.

Hudson River and East River Between Lackawanna Station, Navy Yard and Governor's Island.

Average of Daily Observations at Various Hours for Two Weeks.

Type of vessel.	Visible at one time.	Speed miles.	Beam feet.	Draft feet.	Area disturbed per minute. Square feet.
Ferries	7.5	14	40	12	369,000
Tugs	16.9	10	22	12	327,000
Tugs and Tow	6.6	7	100	12	407,000
Ocean Steamers	0.23	14	70	24	20,000
Schooners	0.39	7	30	14	7,000
Total					1,130,000

The total area disturbed calculated as described was found to be 1,130,000 square feet per minute. The total area of waters under observation is approximately 108,000,000 square feet. The proportion disturbed per minute is therefore 1/105 and the average time elapsing between successive disturbance of the same point is the reciprocal of this, or 105 minutes. The average draft is twelve feet so that it may be said that once in 1.75 hours any particular portion of the water of the Hudson or East River is stirred to a depth of 12 feet. Assuming such stirring to represent complete mixing, the data is now in form for reference to our absorption table. The effect of vessels amounts to but a few per cent of the total effect due to all disturbances.

Effect of Tidal Currents.

The third important agency in the mixing of waters like those of New York Harbor is one which is least noticeable in its action and which is consequently overlooked in general discussions of this subject. This is the vertical circulation due to tidal action. Tidal currents act in at least two distinct ways. There is first the effect of the velocity of the moving stream in passing through a changing cross-sectional area and second the effect of under-run produced at the meeting of fresh and salt water.

When any body of water moves through a cross section which is changing in area or direction local differences in pressure arise which cause vertical and horizontal circulation. To a minor extent, movement in uniform sections, is, owing to bottom resistance, a process of rolling rather than one of strict translation. This effect is aggravated by rough bottoms and by high velocities. In extreme cases "rips" result even where there are considerable depths. Less vigorous action leads to "boils," common upon rivers with irregular sandy bottoms, or in the vicinity of bends.

57 Mixing due to these causes is always quite complete throughout the depth, and owing to the large volumes which pass during a tidal cycle, this agency, where it is active at all, is of importance in the aeration of tidal waters.

In New York Harbor the waters which flow into the East River from the Upper Bay, either through the Buttermilk Channel or around the west side of Governors Island, are visibly subject to this action. At Hell Gate also there is complete vertical mixing of all the water passing. It happens that the volume of water in the East River between Hell Gate and the Battery is approximately equal to that which enters from each end during a half tidal period of six lunar hours, so that the average time between mixing of the waters of this river is about six hours. Some slight additional advantage is also derived from the relatively narrow cross-section and consequent pressure gradients across the current at maximum flow, from the bends and from the influence of Blackwell's Island. These all produce minor partial mixings through the vertical plane so that for these waters an average mixing period of five hours is probably conservative, and will be assumed.

The waters of the Hudson are less subject to action of the kind here described. Its width precludes any material cross-stream pressure gradients due to velocity of flow and side resistance and its uniform depth is not favorable to "boils." A portion of its flow is subject to overturning at Governors Island, but the amount is inconsiderable. The second class of tidal effect mentioned, however, is predominant in the Hudson, namely the effect of under-run. A careful study throughout the tidal cycle, as given by the U. S. Coast and Geodetic Survey (1) shows that at least once during each flood tide there is a fairly complete commingling of the waters throughout

(1) U. S. Coast & Geodetic Survey, Rep. for 1887, Append. No. 15.

the depth of the stream. This effect is confined to those waters in

which there is distinct stratification and is probably immaterial below Spuyten Duyvil, as indicated in the salinity table published by the Metropolitan Sewerage Commission. (2)

Above Spuyten Duyvil, therefore, an average time between mixings of twelve hours may be safely assumed.

That portion of the tidal prism of the bay and tributaries which passes through the Narrows may similarly be assumed to receive a thorough mixing at that point, but as this incoming water will be composed largely of pure sea water, with an oxygen content approaching saturation the advantage in this case is slight.

In the main body of the Upper Bay and Lower Hudson the mixing from tidal effect is slight at best and cannot be estimated even roughly. The effect of tides rising and falling upon sloping shores, of waves breaking upon those shores, and of minor irregularities in current leading to eddies and boils is at least small in comparison with the effect of Hell Gate for example, and the small additional aeration given to waters passing the latter point serves excellently to indicate the infinitesimal results due to these minor causes.

58 Summary and Conclusion.

These various results may now be summarized and added, as indicated in Table 19. It should be noted in particular that the effect of boats is the maximum effect found in the river and is largely excessive for the upper bay. Similarly the wind action is probably excessive for the Hudson and certainly largely so for the East River. The values are also all excessive in that fresh water coefficients of absorption only were available. It has been purposely intended to give results which shall be maximum values in every case.

TABLE 19.

Average Rate of Absorption of Atmospheric Oxygen in Various Parts of New York Harbor and Tributary Waters When 70 per Cent. Saturated.

Body of water.	Average time between mixing (hours).				Rate of absorption. Pounds per million gallons, per hour.
	Wind.	Boats.	Tide.	All causes.	
Upper Bay, Middle and Lower Hudson:					
Depth of 12 feet	2.8	1.75	....	1.1	0.045
Depth of 20 feet	3.0	....	....	3.0	0.045
Depth of 30 feet	8.0	....	....	8.0	0.040
Depth of 40 feet	24.0	....	....	24.0	0.035
Upper Hudson:					
Mean depth 30 feet	8.0	....	12	4.8	0.012
East River:					
Depth of 12 feet	2.8	1.75	5	0.89	0.048
Depth of 20 feet	3.0	....	5	1.9	0.049
Depth of 30 feet	8.0	....	5	2.3	0.051

(2) Rep. Met. Sew. Comm. of New York, 1910, p. 529, Table IX.

The last column of Table 19 is obtained in the following manner: The upper twelve feet in the bay is completely mixed in the summer time on the average of once in 1.1 hours. Obviously the maximum effect of such mixing would result from a uniform distribution of the mixing periods. In assuming such a distribution therefore, which is the only possible assumption in a general analysis of this kind, the results will show a degree of aeration somewhat in excess of the truth. Similarly we may allow an average period of mixing of 8 hours for the 30-foot, and 24 hours for the 40-foot depths. Referring now to Diagram 6, it is seen that the average rate of absorption in 12-foot depths by water 70 per cent. saturated, during a period of 1.1 hours is approximately .045, and in 20-foot depths during a period of three hours 0.018 pounds per hour per million gallons of water. The values for greater depths have not been plotted, but at 30 feet during an 8-hour period the value is found to be 0.01, and at 40 feet during 24 hours approximately 0.005 pounds per million gallons.

59 In 20-foot depths one million gallons will therefore absorb altogether 0.018 pounds per hour plus the amount absorbed by twelve-twentieths of one million gallons in the upper twelve feet, or 0.027, making a total of 0.045 pounds. Similarly in 30 feet there will be an absorption per million gallons of 0.01 pounds, plus two-thirds of 0.045 pound, a total of 0.040 pound, and in 40 feet, 0.005 pound plus three-fourths of 0.040 pound, a total of 0.035 pound.

In the Hudson River above Spuyten Duyvil, a mean depth of 20 feet is assumed which an average mixing interval of 2.4 hours gives a rate of absorption of 0.019 pound per million gallons. The treatment of the East River is the same as that outlined above.

In each case the absorption in deep layers is determined as defined by their degree of quiescence, and to this absorption by the upper layers due to their more frequent periods of mixing is added.

It is of interest to note that the action of the wind and tide reverses the conditions found in quiescent water, in that the rate of absorption of oxygen per million gallons of water increases slightly with increasing depth down to about 30 feet. With the added action of boats this effect is not so noticeable, and in the final results the combined effect results in a very even rate of absorption so that special treatment of the 12-foot depths need no longer be considered and for all practical purposes the average rate of absorption in the bay and lower Hudson may be taken at 0.045, in the East River at 0.050, and in the upper Hudson at 0.019 pound per hour per million gallons of water in all depths less than 40 feet. The effect of aeration in depths greater than 40 feet may safely be disregarded.

There remains only the discussion of minor tributaries. Of these the Harlem is of the greatest interest. This rapid flowing stream is undoubtedly more thoroughly mixed throughout its course and throughout most of the tidal cycle, than any other body of water dealt with here. The relatively small volume of water passing through the Harlem makes it of minor consequence. Of the other bodies of water tributary to the Bay there is none that is as favorably affected either by wind or tide or vessels as are the Hudson and

East Rivers. There are doubtless many small bays that have shallower depths, but reference to diagram 6, plate 16, will show that even in depths of ten feet, with periods of mixing of twelve hours or more the rate of aeration is not greater than those that have been found in the bay.

60

Chapter III.

Investigations Upon the Aeration of Sewage.

General.

The purification of sewage by biological means may be carried out to any degree of perfection desired and at costs that vary with the efficiency of the process. The most economical of such processes, and the least efficient, as measured by the degree of oxidation resulting, aims at producing complete stability in the organic matter. The effluent from a trickling filter for example, if discharged into a stream, will cause little or no reduction in the dissolved oxygen and natural purifying power of such stream.

Between this condition of practically complete stability and the condition of crude sewage, which is highly decomposable, lies a great range of possible conditions of partial oxidation which may be denoted numerically as lying between the limits of zero and 90 per cent. relative stability upon a scale in which complete stability would be represented by 100 per cent. In studies of sewage disposal by dilution this relative stability factor is one of prime importance since it measures directly the resulting effect upon the waters in question. Hitherto, little if any attention has been given to the problem of producing effluents having stabilities within the range indicated.

The experiments here reported were undertaken to determine if by some suitably arranged plan of artificial aeration, such partial purification could be accomplished at reasonable cost. Since biological filters are but mechanical devices for bringing together in close contact the three elements which enter into the oxidizing reactions, namely sewage, oxygen and bacteria, it was hoped that by increasing the ratio of sewage to oxygen volumes within a given tank space, and thus reducing the space required for purification, partial oxidation would result which would be of value under the peculiar local condition. These experiments were divided into three series. Series I. included investigation in shallow tanks upon both crude and septic sewage. Series II., investigations in a deep tank with septic sewage alone, and Series III., investigations, with a modified septic tank known as a biolytic tank. The first two series were made at Brooklyn and the last at Boston.

Series I.—Aeration of Crude and Septic Sewage in Shallow Tanks.

Plan of Investigation.

The purpose of these experiments was to determine, first, whether the stability of raw or septicised sewage could be increased by forced aeration, and, secondly, under what conditions, with what volumes of air and at what cost the maximum economic efficiency of such a process could be attained. For this purpose arrangements were made at the sewage disposal works located in East New York for pumping directly from the outfall sewer a continuous flow of sewage sufficient for these investigations. This sewage was first pumped to an elevated supply tank from which it flowed by independent lines to a septic tank and to an aerating tank. The sewage from the septic tank overflowed to a second aerating tank; we were thus en-
61 abled to aerate both the crude sewage and the septic sewage.

During a portion of this period of investigation aeration of the septic tank effluent was accomplished by pumping compressed air to the bottom of the tank through six parallel lines of pipe, each furnished with a row of ⅛-inch holes along its top line. For the purpose of better distribution of this air a fine mesh copper gauze was soldered around the air pipe so that the space between the pipe itself and this guaze became virtually an air chamber. During the second period of the investigation in addition to the arrangement just described, the tank was provided with frames upon which common laths were nailed in such a way that vertically and horizontally these laths were about one inch apart and at an angle of 45 degrees. The rows of laths were also staggered both verticallly and horizontally. This arrangement gave throughout the body of the tank a very large surface for the development of bacterial growths upon which we relied for improved efficiency and it also served to improve the distribution and delay the passage of the air as it flowed upward. The aerating tank used with the crude sewage was constructed in exactly this same way at the beginning. The total capacity of the septic tank was 3,200 gallons; of the septic aerating tank 1,495 gallons; and of the raw sewage aerating tank 740 gallons. The average rate of flow through the raw sewage tank was maintained throughout at 13,000 gallons per day, making the period of treatment 1.4 hours. The septic tank and aerating tank were first operated at the rate of 13,000 gallons per day, making the period of septic action 5.9 hours and of aeration 2.8 hours. Later the capacity of the septic tank was decreased one-half as was also the rate of flow, thus maintaining the rate of septic treatment at the same figure but increasing the time of aeration to 5.6 hours. Considerable difficulty has been experienced in maintaining a steady flow of air through these two tanks and in particular in apportioning that flow in the desired ratio. It is believed, however, that the average conditions of air flow and the average results obtained are fairly representative.

Chemical Methods.

Chemical analyses have been made of the raw sewage before and after aeration and of the septic sewage after aeration. In changes in the character of the sewage with reference to its stability or its oxidizability, the ordinary methods of chemical analysis do not indicate the significant factors. One factor of importance is the dissolved oxygen contained in the liquid in question. Of chief importance, however, is that factor which we call the stability of the sewage which is the reciprocal of its tendency to withdraw oxygen from a stream. This stability factor we have estimated in two different ways. The first is known as the relative stability method or more commonly the putrescibility. In this method the liquid is mixed with the different proportions of water containing a known amount of dissolved oxygen. A sensitive indicating dye known as methylene blue is added to the mixture and the whole is preserved in a stoppered bottle and kept under constant observation. This blue dye has the property of losing its color when the dissolved oxygen of the liquid has entirely disappeared. The time required to so decolorize a sample is a somewhat complicated logarithmic function of the stability. This function has been determined as the result of an extended series of investigations upon all classes of sewages
62 and effluents so that we now have a well-defined relation between the time required for decolorization and the so-called relative stability. This relative stability is the ratio between the amount of oxygen available in the diluted sample and the total amount of oxygen which would be utilized by that sample in its complete oxidation. Thus a sample of such a mixture which had a relative stability of 50 per cent. would contain just half the amount of oxygen which would be required to render it perfectly stable. This method is easy of application and is the one most commonly employed in sewage work. A more delicate method for obtaining the same information, and one which was devised for this work and used here for the first time is the following:

Suitable mixtures of the sewage in question with oxygen-saturated water are made and the total amount of oxygen in the mixture determined immediately. The sample is then stored in a tight bottle for a suitable period of time and a redetermination of the amount of dissolved oxygen present is made. The rate at which the oxygen disappears under these conditions gives us an index of the oxidizability of the organic matter and a more direct measure of the probable effect upon the stream than is given in the methylene blue method. The theoretical basis for this method will therefore be discussed in some detail.

Considering the reaction taking place between the organic matter of the sewage and the oxygen dissolved in the water the following relation should hold

$$\frac{dO}{dt} = K\,O\,C$$

In which O is the amount of oxygen present in unit volume, C the amount of organic matter oxidizable, t the time allowed for the reaction to proceed, and K a constant determined by the character of the organic matter and in turn defining the oxidizability of that organic matter. Integrating

$$\log \frac{O'}{O} = K\,C\,t$$

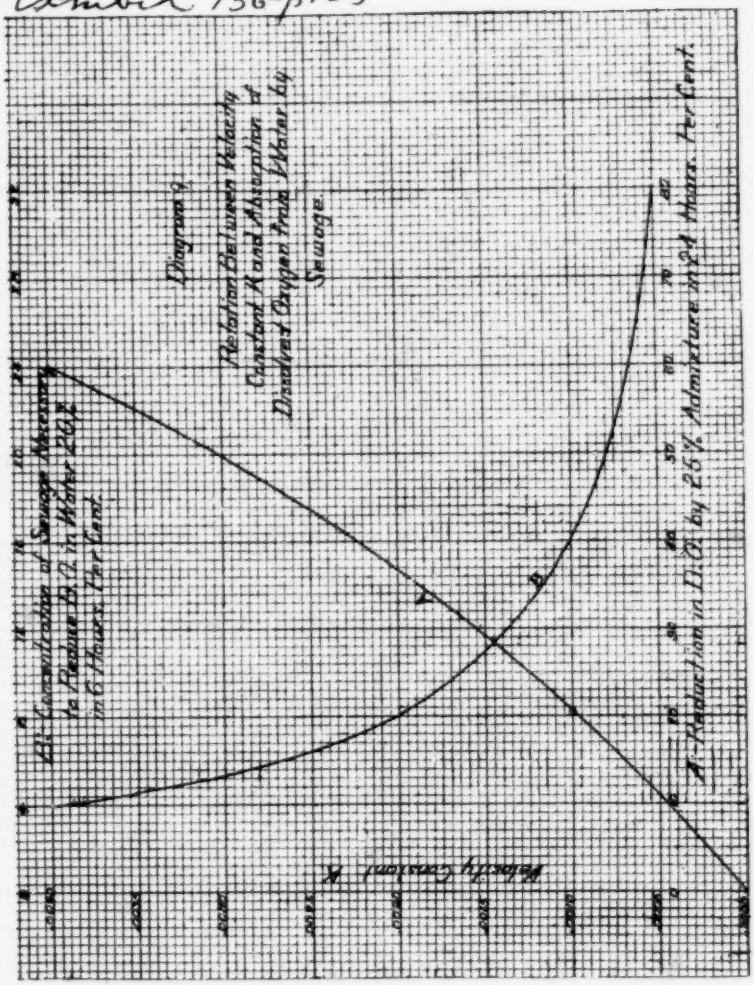
O′ being the initial and O the final amount of oxygen present.

The constant K defines mathematicallly the rapidity with which the oxygen is used in a mixture of water and sewage. It depends upon the character of the sewage matter and the concentration of that material in the sewage and is independent of the extent of dilution or character of diluting water. A value of K = .0030 would indicate a sewage which in 25 per cent admixture with water would reduce the oxygen content of the mixture 50 per cent. in four hours. Similarly for K = .0020 the reduction in a 25 per cent. admixture in four hours would be 37.5 per cent. and with K = .0015, 28.5 per cent. These figures are tabulated in column A below to serve as a standard for interpreting the results of our experimental work.

In column B a set of figures are given which show the percentage of sewage of given K value which could be discharged into a stream under the condition that the oxygen of that stream shall not be reduced more than 20 per cent. in six hours.

(Here follows diagram 9, marked page 63, Complainants' Exhibit 136.)

Exhibit 136-p. 63



64

K	A	B
.0030	50.0%	5%
.0020	37.5%	8%
.0015	28.5%	11%
.0010	20.0%	16%

A—Reduction in dissolved oxygen which would result at the end of four hours in a 25 per cent. admixture of sewage in water.

B—Maximum concentration of sewage permissible if the oxygen shall not be reduced more than 20 per cent. in approximately a half tidal period of six hours.

The relationship is shown more fully in Diagram 9.

Results Obtained.

Chemical Analyses.—Samples were collected daily throughout most of the period covered by the work. During the latter part of the period they were collected every other day. Composite samples, preserved with chloroform, were analyzed weekly. The results are given in Table 20 in the form of monthly averages. For comparison an average analysis of Boston sewage is given.

TABLE 20.

Monthly Averages of Sewage Analyses Made on Samples Collected Daily at East New York, Before and After Experimental Treatment, and Average Analysis of Boston Sewage.

Month.	Suspended solids.			Oxygen consumed.			Nitrogen as organic.			
	Total.	Vol.	Fixed.	Total.	Dis.	Susp.	Free amm.	Total.	Dis.	Susp.
Crude Sewage.										
April	73	48	25	90	71	19	38	29	22	7
May	52	38	14	73	61	12	57	14	10	4
June	53	35	18	71	63	8	53	14	10	4
July	71	46	25	76	60	16	46	16	12	4
August	92	61	31	64	58	6	40	16	12	4
*September ...	113	86	27	76	65	11	46	28	22	6
Average:										
1st Series...	68	44	24	75	63	12	46	18	14	4
Grand Av..	75	52	23	76	63	13	46	20	15	5
Crude Sewage Aerated.										
April	78	47	31	68	51	17	39	23	19	4
May	54	34	20	53	42	11	33	16	13	3
June	101	57	44	56	46	10	33	15	12	3
July	56	34	22	55	46	9	36	15	12	3
August	94	65	29	57	47	10	34	15	12	3
Average..	76	47	29	58	47	11	35	17	13	4

*Second series of experiments begun.

65

Month.	Suspended solids.			Oxygen consumed.			Nitrogen as organic.			
	Total.	Vol.	Fixed.	Total.	Dis.	Susp.	Free amm.	Total.	Dis.	Susp.
Septic Sewage Aerated.										
April	54	38	16	57	38	19	24	21	17	4
May	34	23	11	52	40	12	26	16	11	5
June	58	34	24	56	40	16	27	17	15	2
July	54	26	28	56	41	15	27	16	12	4
August	42	31	11	42	38	4	26	14	11	3
*September ...	72	51	21	49	46	3	24	25	20	5
Average:										
1st Series...	49	26	23	53	39	14	26	17	13	4
Grand Av..	51	32	19	52	41	11	25	18	14	4
Boston Sewage.										
Sept.-Dec.	185	130	55	66	27	33	21	3.1	1.7	1.4

* Second series of experiments begun.

The high nitrogen values indicate a sewage much stronger than the average and possibly containing nitrogenous manufacturing wastes, such as brewery waste. The low suspended solids on the other hand indicate a considerable deposit in the outfall sewer. Considering the strength of this sewage its stability is high. The sewage of Boston is fully as putrescible as this sewage, measured in terms of oxygen absorption from water, but in chemical composition it is much weaker. This bears out the indication of some relatively stable manufacturing waste. It would appear that we are dealing with a sewage which, although strong according to our analytical results, is not more decomposable than an average city sewage. Improvement by aeration would, therefore, be relatively more difficult.

The analyses of the crude sewage after aeration and of the same sewage after having passed the septic tank and the aeration tank are also given in Table 20. No changes are noted other than those which can be ascribed to the action of the tanks themselves.

Relative Stability.—The relative stability results as determined by the methylene blue test are given in Table 21.

66 TABLE 21.

Relative Stability, Dissolved Oxygen and Putrescibility Results and Other Data.

Series I.

Sewage.	Period.	Air., cu. ft. per gal.	Time of contact, hours.	Relative stability dilution %.					Putrescibility coefficient K dilution %.		Dis. oxygen.
				15	20	25	30	35	5	25	
Crude.....	1	...	...	80	66	53	45	..	.0029	.0035	1.9
Crude, Aerated	1	.20	1.4	95	96	77	69	61	.0020	.0020	2.3
Crude.....	2	...	...	75	57	43	..	..	.0054	.0060	2.8
Crude, Aerated	2	.09	1.4	..	..	74	63	52	.0023	.0044	1.1
Crude.....	3	...	...	86	70	60	..	..	.0059*	.0040*	1.2
Septic, Aerated	3	.36	2.8	95	95	79	61	48	.0027*	.0026*	.34
Crude.....	4	...	...	82	68	60	..	..	.0028	.0026	2.7
Septic, Aerated	4	.67	5.6	..	..	68	56	45	.0017	.0023	.37
Crude.....	5	...	...	74	58	48	..	..	.0038	.0036	3.1
Septic, Aerated	5	.77	5.6	..	..	78	70	68	.0014	.0021	1.2
Crude.....	6	...	...	79	59	44	..	..	.0076	.0104	2.5
Septic, Aerated	6	.23	2.8	..	..	83	80	69	.0018	.0054	.22

* These dilutions are 10 and 50 instead of 5 and 25.

Period 1—March 25 to May 17.
Period 2—May 18 to August 19.
Period 3—March 25 to April 21.
Period 4—April 22 to May 12.
Period 5—May 13 to June 26.
Period 6—June 27 to August 19.
Baffle screens used during Periods 1, 2, 5 and 6.

The raw sewage shows a constantly decreasing stability as is always the case during this season of the year. Direct aeration at the rate of .20 cubic feet of air per gallon of sewage increases the stability by about 45 per cent. in a 25 per cent. mixture, and 53 per cent. in a 30 per cent. mixture. During the second period the rate of application of air was decreased to 09. and the increased stability for this period in a 25 per cent. mixture was 72 per cent. It is possible that still less quantities of air would give results approximately as good, but upon the basis of this work it is evident that no greater quantities than 90,000 cubic feet per million gallons will be required.

The septic sewage results must be considered in four separate periods. During period "3" the rate of application was .36 cubic feet per gallon, and the increased stability over the raw sewage for the corresponding period was 32 per cent. in a 25 per cent. mixture; during the fourth period the time of contact with the air increased from 2.8 to 5.6 hours, the other conditions remaining the same except that now the rate of application of air was .67 cubic feet per gallon. The stability in 25 per cent. mixture was increased only 13 per cent. During the fifth period screens were installed similar to those already in use with the crude sewage, the rate of application and time of contact remaining the same, which resulted in an increased stability of 62 per cent., calculated on the crude sewage for

this period. During the sixth period the air was diminished
67 to 0.23 cubic feet per gallon, and the time of contact to 2.8 hours, with a resulting improvement in stability at 25 per cent. dilution of 89 per cent., the highest value recorded during these studies. A part of this improvement is doubtless due to the decreased stability of the sewage itself already noted, and the same statement may be made in regard to the second period of the raw sewage experiment, in which decreasing the amount of applied air did not materially affect the result. The results of these last periods are approaching summer conditions and it is doubtless true that with the coming of warm weather and the consequent lessened stability of the crude sewage, high percentages of improvement are more readily obtained. As it is summer conditions that really limit any dilution process of sewage disposal, these warm weather results have the greatest significance in this present study.

Putrescibility Coefficient.—The results obtained by the putrescibility coefficient are, when suitably interpreted, the most satisfactory basis for determining the results of the work of this character. In Curve B, Diagram 9, the maximum permissible concentration of sewage in a body of water is given for all values of the coefficient, under the condition that the dissolved oxygen shall not be reduced by more than 20 per cent. in six hours. For purposes of comparison any other value might have been selected. Measured by this practical test the percentage improvements in the sewage under treatment as shown by the data of Table 21 were as follows:

TABLE 22.

Percentage Improvement in Condition of Sewage Brought About by Aeration, as Measured by Concentration of Sewage Required to Reduce the Oxygen Content of Water 20 per Cent. in Six Hours.

Summary.

Period.	Improvement, per cent.
1	45
2	136
3	118
4	65
5	177
6	320

Full discussion of these results will be reserved for a later place.

Series II.—Aeration of Septic Sewage in a Deep Tank.

Our investigations up to this time had shown that a satisfactory partial oxidation of crude sewage could be accomplished under the conditions prevailing in the experiments. The volume of air required relative to the sewage flow was considerable, however, and the cost of such treatment seemed unnecessarily high. Examinations of the air leaving the aeration tank showed conclusively that the oxygen content was far from being exhausted. In fact, the air was

practically of normal composition upon leaving the tank as far as we could learn from chemical analysis. In other words, the actual amount of oxygen absorbed from this considerable volume of air was infinitesimal. It seemed therefore that the same body of air might to good advantage be used to treat a larger volume of
68 sewage at a consequent decreased cost of pumping. This result could only be obtained by increasing the depth of the tank. In two tanks of unequal depth through each of which sewage is flowing at a stated velocity and into each of which a stated volume of air is passing, the sewage in that tank having the greater depth will obviously receive exactly the same treatment as that in the smaller tank, but the relation of air volume to sewage will be inversely as the depths.

Plan of Investigation.

To test the efficiency of this procedure, a tank twenty-one feet in depth to the water line was built out of two-foot lengths of 24-inch vitrified sewer pipe set up in a vertical stack. Through the central axis of this stack a three-quarter-inch iron pipe passed from top to bottom and upon this pipe circular discs of No. 12 expanded metal lathing were placed at one-foot vertical intervals. Sewage was admitted to this stack through a two-inch pipe at the bottom, this pipe coming from the overflow in the septic tank used in our previous experiments. The sewage overflowed from a pipe at the top of the stack. Compressed air was pumped through the three-quarter-inch iron pipe mentioned and was distributed at the bottom of the stack through one-eighth-inch holes spaced two inches on centers upon four cross arms 90 degrees apart, extending from the center to a point near the periphery. Compressed air was supplied by the compressor used in the previous experiments. The capacity of the air compressor was determined under the working conditions by inserting a pressure air meter in the line and calibrating the pump by revolutions. Subsequently the rate was controlled by pumping as nearly as possible at a fixed number of revolutions and wasting the desired amount through a by-pass which was metered. The actual amount of air used was then taken as the difference between the original pump rate at the given speed and the amount of air measured in the waste line. The experimental portion of this work was divided into two periods:

During the first, a four-hour period of septic treatment and a one-hour period of aeration were allowed. The rate of flow of sewage through the tank during this period was 486 gallons per hour and of air about 110 cubic feet, so that air was being applied at the rate of approximately 0.23 cubic feet per gallon.

During the second period, the rate of flow throughout the system was reduced one-half, so that the time of septic treatment was made eight hours and of aeration two hours. The volume of air was decreased proportionately, so that the net effect of this change was to increase the time of treatment only.

Results Obtained.

These experiments were controlled by the same chemical tests as were made in the first series. They extended from September 10 to September 23, in the first period, and from September 23 to October 6 in the second period. As the sole purpose of this series of experiments was to determine whether results comparable with those obtained in Series I. could be obtained in the deeper tank at a correspondingly less volume of air relative to sewage, it was not continued longer than was necessary to demonstrate the facts. The average results of each period as measured by the two methods already described are summarized below.

TABLE 23.

Relative Stability, Dissolved Oxygen and Putrescibility Results and Other Data.

Series II.

Sewage.	Period.	Air, cubic feet per gallon.	Time of contact, hours.	Reltive stability, dilution per cent.					Putrescibility coefficient K, dilution per cent.		Dissolved oxygen.
				20.	25.	30.	35.	40.	5.	15.	
Crude	1	....	..	78	60	49	..	..	.0054	.0058	2.0
Aerated septic	1	0.23	1	..	..	94	85	77	.0011	.0015	6.2
Crude	2	....	..	80	68	52	..	..	.0069	.0080	.80
Aerated septic	2	0.23	2	..	..	77	62	44	.0028	.0044	4.4

70 In interpreting these results it is necessary to bear in mind the fact already developed early in these investigations —that the putrescibility of the sewage itself changes greatly from season to season, largely owing to temperature changes. Therefore the ratio of improved stability obtained in this series of experiments is the point of particular significance. No direct comparison of actual K values or of stabilities as determined by the methylene blue test can be made between these results and those of the first series, which were made during the warmer summer months.

The improved stability as measured by the methylene blue test at 20 per cent. is 93 per cent. in period one (1) and 48 per cent. in period two (2), and as measured by the putrescibility coefficient 380 per cent. and 145 per cent., respectively.

On the whole, it is seen that the relative improvement is decidedly greater than was observed in Series I. It is not certain that results of maximum efficiency are obtained in this case, owing to the comparatively small amount of air necessary; the compressor in use could not be controlled at any lower rates, but the evidence indicates that satisfactory results could be obtained with relative air volumes somewhat less than those actually used.

Analyses of the air escaping from the top of the tank were made on several occasions and showed that about 2 per cent. by volume of the total amount of air passed, or 10 per cent. by volume of the oxygen content of that air had been exhausted in its passage through the tank. It is therefore apparently only a matter of engineering economy in the construction of deep tanks which will determine the most economical depth to be employed. Obviously the economy of this treatment increases in direct proportion to the depths of the tank.

Series III.—Experiments Upon the Aeration of a Biolytic Effluent, at Boston, Mass.

The two series of investigations which have been reported thus far made use of a septic tank effluent which was at all times devoid of oxygen and was throughout a considerable period of this work exceedingly putrescible. It is a well-known fact in sewage chemistry that with increasing age of sewage there is a corresponding decrease in oxygen dissolved values and that this change does not end when the zero value is reached. Under the anaerobic conditions which then result, the sewage becomes exceedingly avid for oxygen so that an old septic effluent will oftentimes absorb almost immediately more oxygen than the original sewage would have absorbed in many hours. There is reason to believe that this increased avidity for oxygen is due in a large measure to easily oxidized gaseous or mineral compounds, so that oxygen used up in accomplishing such oxidation is largely wasted. On the other hand, it is quite possible that this increased avidity is a direct measure of the ease of oxidation of the entire mass of the organic matter, in which case these conditions are distinctly favorable. The results of the first series of investigations reported seemed to indicate that other things being equal a septic effluent would rapidly use up a larger amount of oxygen than

with a corresponding crude sewage with no additional beneficial results in the matter of stability than those which could be ascribed to the partial loss of suspended solids which is incidental to the septic process. It was thought best, therefore, to obtain more data upon the question of the desirability or otherwise of first septicizing the sewage before aeration.

71

Plan of Investigation.

At the Sewage Experiment Station of the Massachusetts Institute of Technology, a tank of somewhat novel design has been in operation under the direction of one of the writers for about eighteen months. This tank has been called a "biolytic" tank. It is essentially a deep rectangular tank with a hopper-shaped bottom. The sewage enters through a pipe down the center and is discharged at a point near the bottom of the tank. It flows upward in a column whose cross section is constantly increasing and whose velocity is consequently decreasing, overflowing at eight points about the periphery. The purpose of this tank and of this peculiar mode of operation is to prevent the accumulation of the products of decomposition in the bottom layers and to keep the sewage as fresh as possible consistent with satisfactory sedimentation. The tank effluent is well clarified and in much more satisfactory condition for treatment upon sand filters or other oxidizing mechanisms than is the effluent of the septic tank.

The aeration system was installed in the upper two feet of this tank, essentially similar to the arrangements used in the first series of these experiments. Our results thus far having indicated the possibility of increased economy with increased depth, the question of depth and relative volumes of air are not deemed of importance in these experiments. If satisfactory results could be obtained during a stated period of treatment such as one or two hours the economy in air compression which would result from the use of deeper installations could easily be determined. The installation, therefore, consisted of a series of seven horizontal air distributors essentially like those already described, above which was a system of inclined slats like those used at Brooklyn, two feet in depth. This tank had a cross-sectional area at the top of approximately 50 square feet. The rate of flow through the tank was eight thousand gallons in twenty-four hours, which gives an upward velocity in the upper section of 0.88 feet per hour. The time of exposure to the air was therefore approximately two and a quarter hours.

Results.

Results by the putrescibility coefficient only were obtained in this series. During the experiments putrescibility coefficients were obtained at a great many dilutions in order to determine thoroughly the significance of this test. The averages of all coefficients obtained during the period, October 1 to December 31, 1910, were

Crude sewage	.0022
Septic aerated	.0020

which by Diagram 1 gives an improvement of 10 per cent., as measured by the dilution of these sewages which will reduce 20 per cent. of the oxygen of the water in six hours.

This poor showing is evidently due to difficulty in getting aerobic conditions established in the tank which had been anaerobic
72 for over a year. During the months of November and December, when improvement was most difficult in Brooklyn, the average results of the Boston tests made at 5 per cent. dilutions were

Crude sewage	.0023
Septic aerated	.0012

The improvement here, measured as before by Diagram 9, is 92 per cent. These results show strongly the necessity for a separate aeration tank following the septic treatment. The two processes cannot be combined in one tank.

Conclusions.

Amount of Air Required and Improvement Effected.

The amount of oxygen necessary to give significant results has been determined regardless of cost or other considerations. In the case of the crude sewage it was found that a rate of application of 110 thousand cubic feet per million gallons gave an excess of dissolved oxygen in the sewage which indicated that no further advantage would be obtained by increasing the air supply. In the case of the septic sewage an equal rate of application gave no such evidence of excess and an effort was made to add the air at a sufficiently high rate to show some excess. This effort was only partially successful and in no case was the excessive oxygen in this effluent as great as in the raw sewage effluent. For this reason also the time of contact was doubled without any appreciable results in the excess of oxygen. It was soon discovered that it was useless to attempt to get any noticeable excess in this septic sewage and that even at the lower rates the stability of the septic sewage was increased and at the higher rates of application was fully equal to that of the aerated crude sewage. Analysis of the air leaving the liquid also showed that the absorption of oxygen from this air was very little indeed so that it seemed desirable to decrease rather than to further increase the amount. The result obtained during period 6 amply justified this conclusion. These results are so far superior to those obtained with crude sewage, that there is every indication that highly satisfactory results could have been obatined at still lower rates of treatment.

Imperfect distributing apparatus made it impossible to further reduce this rate and study this matter further in the limited time that was available. The results of Series II. are of especial interest in indicating still further economy in air. The much greater effi-

ciency obtained during the first period of treatment indicates a distinct advantage in favor of shorter period of septic treatment. Again it was found impossible with the large capacity of the air compressing machinery and meters to reduce the air flow to what was strongly indicated as the point of maximum economy.

The Boston experiments were not planned to determine possible economy in air since only a shallow depth was available, but the result of all this work taken together enabled conclusions to be drawn that were not indicated in any single series. Period 6 of Series I, gave the best results in a shallow tank with an air consumption of 0.23 cubic feet per gallon and a contact period of 2.8 hours. Series II, shows that economy in air and tank space, and efficiency increase with the depth, other conditions being equal. Together with Series III, it indicates a great advantage in short septic periods. All the data taken together plainly show that, during the hot weather months, the critical period in harbor conditions, the stability of a sewage as measured by its withdrawal of oxygen from the diluting waters, can be increased from two to three fold by the application of short period septic action, and by aerating in a deep tank; and that an air consumption of approximately 0.1 cubic feet per gallon will doubtless be sufficient under these conditions. This means that under any stated conditions of permissible pollution in the harbor waters the maximum amount of sewage which can be disposed of in the harbor is increased two to three fold by this treatment.

73

Sludge.

The question of sludge disposal is one which is common in all sewage treatment and has not been investigated here. The Biolytic tank in use at Boston is designed with special reference to this problem. Its function is to reduce the sludge problem to a minimum by providing for maximum liquifaction in the tank. Results of the operation of the tank will soon be published in another place. It can be stated that the sludge problem will at least be not greater than in other processes and can by proper design of tanks be very much reduced if desirable. The amount of finely divided suspended matter which the tank will discharge is controlled by the design. The amount which should be discharged under any given local conditions can only be determined by local studies. It will be found advantageous to discharge a maximum quantity as determined by stream flow and dilution in any case. The remainder will have to be dealt with by methods now in vogue, most likely by removal in scows.

Cost of Aeration.

The relative costs of low pressure air compression by means of compression and rotary blowers has not been gone into in detail. There would seem to be some advantage in the use of deep tanks and higher pressures, up to possibly thirty feet. On the other hand for lower pressures, up to five or six feet, the blower type of air pump is highly efficient.

A blower of this type having a capacity of fifty thousand cubic feet of air per hour under a five-foot head of water requires about 25 K. W. of current, net.

At the rates of aeration which we have finally adopted, this blower would care for a sewage flow of half a million gallons per hour. At a cost of 4 cents per K. W. hour these costs for current alone would be two dollars ($2) per million gallons. This refers to small electrically operated plants at sewer outfalls. For larger installations, the cost of power would not exceed one-half this amount. We estimate the total cost of installation of plant in the neighborhood of two thousand dollars ($2,000) per million gallons daily capacity, or about one twenty-fifth the cost of sprinkling filters after deducting land costs. Labor charges should be exceedingly low.

It should further be noted that under conditions in which such a process might be necessary and sufficient, the necessity for
74 its use would arise only during the summer season, of perhaps four months each year. If winter conditions demand treatment at all then the summer conditions would not be met by aeration, since the variations we have noted between summer and winter sewages are greater than the improvements obtained.

Under certain local conditions also less perfect results than have been obtained here might be ample. The merits and possibilities of this process have only been barely indicated in this investigation and a fruitful field has been opened up for future investigation.

75

Chapter IV.

Studies for Sewage Disposal from Certain Districts.

Flushing Drainage District.*—This district is bounded on the south by the ridge near Hillside road, which forms the divide of the watershed to north and south; on the west by Flushing Bay and the high land west of Flushing Creek; on the north by the Sound and on the east by Little Neck Bay and the low lands extending from the head of that bay to the ridge first mentioned. The total area is 14,923 acres, and the estimated future population on a basis of 50 persons per acre for the towns and 25 persons per acre for suburban districts, is 423,425. For the purpose of determining possible points of discharge a trunk sewer system had to be designed, on the separate system for the unsewered parts and with storm water overflows where the combined system is now installed. This system as designed serves all of the district and is adequate to the needs of the estimated future population. A water consumption of 125 gallons per capita per day was assumed and an allowance of .003 cubic feet per second per acre was made for ground water flow, based on the practice of the Borough Engineer of Brooklyn. Further assumptions made were as follows: that of the total

* See map showing Drainage Districts of Jamaica, Corona, Flushing and Westchester following p. 148. The writers are indebted to Mr. E. F. Robinson for valuable assistance in the Drainage District Studies.

flow per 24 hours, half would pass in eight hours; that the maximum velocity with sewer 0.8 full should not exceed 7.5 feet per second; and that the minimum velocity with sewer 0.2 full should not be less than 1.50 feet per second.

It was found that the drainage from the entire area could be brought to a point in the East River east of Powells Cove and then discharged, and that five-sevenths of the area could be drained by a high level gravity system to the point of discharge, with a low level gravity system for the remainder, discharging into the high level system by pumping. Possible sites for purification works were found should such prove necessary. Details of the recommendations made are given in the special report rendered March 20, 1910.

Corona Drainage District.*—This district comprises the territory between the Flushing District on the east, the dividing ridge on the south, the Borough of Brooklyn and Newtown Creek on the west and the East River on the north. Its area is 14,535 acres and the estimated future population on the basis described for the Flushing District is 628,200. This includes an area of 756 acres with an estimated future population of 37,800 for which the natural drainage is through the sewers of Brooklyn. Another portion containing 1,290 acres with an estimated future population of 64,500 along the water front from Astoria south and west to Newtown Creek and lying below the 20-foot contour, is now drained into Newtown Creek and the East River. Eventually its sewers will have to be intercepted and discharged by pumping into the main system.

For the remainder of the district a gravity system of trunk sewers has been designed by which all of the sewage is carried to and discharged into deep water of the East River from a point approximately to the southeast of Berrians Island.

76 Should purification works become necessary, these can be located on Rikers Island, to which the system can be prolonged.

The sewers were designed on the same assumptions as those for the Flushing District. Provision for storm water overflows has been made at points where the proposed interceptors receive the discharge of existing combined systems, and at two points along Flushing Bay and one point near the head of Newtown Creek. While the sewers were designed for sanitary and ground water flow only, they are of capacity sufficient for the estimated future population and until the present population shall have increased greatly they can be utilized for storm water flow.

There is now a sewage purification plant at Elmhurst, which is capable of caring for the sewage of the district tributary to it for the present and if improved can be utilized for the increasing population for some years and thus render unnecessary the immediate construction of a portion of the projected system.

Full details of the system as projected are given in the special report dated May 24, 1910.

Jamaica Drainage District.*—This district comprises the areas draining naturally into Jamaica Bay as well as Coney Island, Rockaway Beach and a small area near the head of Little Neck Bay, within the limits of Greater New York, but cut off by a ridge from the Flushing District system. In general it is bounded on the north by the ridge which forms the southern limit of the Corona and Flushing Districts, on the east by Nassau County, on the south by Jamaica Bay and on the west by Gravesend Bay.

The estimates for future population were made as in the other districts. Inasmuch as it is expected that the portion of the district contiguous to Jamaica Bay, for which a population of 50 per acre has been assumed, will be developed chiefly for manufacturing and commercial purposes, a water consumption of 100 instead of 125 gallons per day has been allowed, which gives an equivalent population of 40 per acre with a water consumption of 125 gallons per day. In the cases of Coney Island and Rockaway Beach, the permanent population is small in comparison with the number of daily visitors throughout the summer months. For Coney Island a maximum population of 500,000, with an average daily water consumption of 15 gallons per capita, has been assumed, and it is further assumed that the total run-off will take place in 12 hours. These assumptions when reduced to terms corresponding to those used for other districts would give a permanent population of 70 per acre with a daily per capita water consumption of 125 gallons. Similar assumptions for the Rockaway section give an equivalent permanent population of 50 per acre, with a daily water consumption of 125 gallons. Other assumptions as to population, water consumption, ground water run-off and ratio of maximum to average discharge are the same as for the FlushingDistrict.

The total area in the Jamaica District is 48,916 acres. The total estimated future population is 1,661,495.

Jamaica Bay is a land-locked tidal basin of slight depth, in which the entire tidal prism is filled and emptied during each tidal period.

77 Partial purification of the sewage discharged into it will be required, but even with such purification, to secure an adequate degree of diffusion there must be several points of discharge. For the portion of the Jamaica Bay drainage area of the Borough of Queens, the system as projected gathers all of the sewage by gravity at two main concentration points, one at the present Twenty-sixth Ward Pumping Station, and one on Cornell Creek, from which it will be discharged through iron force mains into Fishkill and Broad Channels, respectively. When under the proposed project for improvement of Jamaica Bay, a thirty-foot channel has been formed along the north side of the Bay as far as these discharge mains, they must terminate in that channel, and it will then be essential to provide the most efficient means of diffusion practicable on discharge in order to avoid the formation of local nuisances. Storm

* See map showing Drainage Districts of Jamaica, Corona, Flushing and Westchester, following p. 148.

water overflows are provided whenever existing sewers of the combined system are intercepted.

The eastern section of the Borough of Brooklyn comprised in the Jamaica District already had approved plans for sewerage, and the project had to be formed with due regard to these plans. The project contemplates the collection of the sewage by gravity at three points where it is lifted to a higher level and conveyed by gravity to proposed purification works in Riches Point Meadow, and then lifted and discharged into Rockaway Inlet, the ebb currents from which pass seaward, without touching the bathing beaches of Coney Island or Rockaway Beach.

The western sections in the Borough of Brooklyn are already provided with approved projects partly carried out. In the complete project only a few additions were required.

Two distinct systems of disposal are practicable for the Coney Island sewage. One is to force the sewage north to the concentration point established for the sections to the north and thence to lead and discharge it into the Narrows, through the interceptor already constructed. The second is to discharge it to the south by pumping into the sea, not less than 2,000 feet from shore, and at a point from which currents do not lead to the beach. The latter plan is recommended, since the inadvisability of increasing the pollution of the harbor in any case where it can be avoided is manifest.

The Little Neck Bay section is of a limited area. It is proposed to concentrate the sewage from it at the head of Little Neck Bay and after purification to discharge it into the bay.

The Rockaway section is low and flat. It is proposed to collect the sewage from it at three points, and after coarse screening and sedimentation with liquefaction for a short period in hydrolytic tanks, to discharge it into the sea at least 1,000 feet from the shore line, from which there is no probability of its being brought back to any appreciable degree.

Disposal in Jamaica Bay.—As stated earlier, Jamaica Bay is a land-locked tidal basin, of which the tidal prism is filled and emptied during each tidal period through Rockaway Inlet. After passing the fanshaped bar between Rockaway Point and Coney Island, outside the outer extremity of the inlet, the inlet has a deep channel of ample width which extends as far east as Barren Island. There this main channel is divided into several minor channels. One follows the north shore of Rockaway Point, others pass northeast between the islands of the bay, and the most westerly follows generally the west shore of the bay. These channels are
78 formed and maintained by the tidal currents. But there is no current circulation between the heads of the channels along the north side of the bay other than such as may be produced temporarily by wind action. Excepting as moved by the winds, the waters on the north and east shores are quiescent. Under such conditions it is evidently necessary that the sewers be extended into the channels as in the project.

The total flow through Rockaway Inlet as determined by the observations of the Engineer Department, U. S. Army, is for flood 4,550,000,000 cubic feet. This is the measure of the tidal prism. From the map of the bay the portion of the tidal prism tributary to each channel was determined and from this the mean velocities of flow in the channels calculated. Assuming the sewage discharge through each of the outlets on the basis as calculated for the project and beginning with pure water in the bay, the amount of partially polluted water due to the discharge at the close of an ebb tide and remaining in the channel at the beginning of the flood period was determined and the ratio of sewage to pure water obtained. It is evident that this ratio is at first too large, since at first no previous pollution is assumed. By continuing the process the ratio grows smaller by decreasing decrements until the decrement practically vanishes and the ratio then represents the true proportions of the average admixture of sewage and sea water which result from the discharge of the assumed volume of sewage. While the dilution figure fairly represents an average condition, the pollution in the immediate vicinity of the sewer outlet will be much greater even with the best process for diffusion possible, and to avoid local nuisance, it will be necessary to have the dilution ratio large. We believe that this figure should not be lower than 1 part sewage to 117 parts sea water at 63 degrees Fahrenheit.

The sewage discharged into Rockaway Inlet from Riches Point Meadow, if considered alone, would have an ultimate dilution, determined as indicated, of one part in 2,670, but when considered together with the discharge into other portions of the bay the average ultimate dilution is 1 in 209. The discharge into Big Fishkill Channel will have an average ultimate dilution of 1 in 75. That discharged into Broad Channel will have an average ultimate dilution of 1 in 95. These figures are based upon an assumption of thorough diffusion. At periods of slack water the percentage of pollution will be much greater.

The dilution ratio of 1 in 117 was adopted as necessary in view of the volume of oxygen absorbed by sewage under summer conditions (1,950 pounds per million gallons in 12 hours), the available supply in the tidal basin, and the consideration that under the worst conditions this supply must never be reduced below 50 per cent. of the saturation value, which would make an average reduction to 75 per cent. of saturation value a standard with a small margin of safety.

Complete purification before discharge is evidently never necessary under the conditions prevailing in Jamaica Bay with sewage concentrated and discharged under the project outlined in this report. During the winter season even partial purification will probably be unnecessary. Therefore, we recommend for this district purification by aeration as described in this report as being
79 most economical and advantageous. Even this treatment will probably be unnecessary until the proposed drainage

system shall have been developed to at least one-half of its ultimate capacity.

Details of the project are given in the special report dated November 18, 1910.

Borough of Richmond Drainage District.*—This district includes all of Staten Island with an area of 36,623 acres, shaped roughly in triangular form with its vertex to the south and its greatest length from the vertex to near the centre of the base at the outer end of he Kill von Kull, on a line running northeast and southwest. It is bounded on the north by the Kill von Kull and the Upper Bay; on the east by the Narrows and the Lower Bay; on the south by the Lower Bay and on the west by the Arthur Kill. The total length of coast line is 36 miles, of which 18 miles border on the two Kills and 5 miles on the Upper Bay. Both Kills are now polluted by sewage from the cities of New Jersey to an extent which probably makes further discharge of sewage into them inadmissible. Tidal and current data are meagre, but the following discussion of the circulation in the Arthur Kill, based on the best information obtainable, confirms this opinion. An examination of the tidal curve of the current charts in Appendix No. 9 of the report for 1886 of the U. S. Coast and Geodetic Survey shows that the tide has risen to 1.51 above mean low water at the beginning of the flood currents and that the plane of the water rises to high water (+4.1) and falls to an elevation of +2.35 before the current begins to run ebb.

It is estimated that the amount of water in the Arthur Kill below the low water plane is about 1,973.5 million cubic feet; that the tidal area is about 123.34 million square feet; and that the ebb and flood flow through the cross-section at Elizabethport is 319.0 million cubic feet.

TABLE 24. SHOWING DATA FOR ARTHUR KILL.

Area.		Elevation at beginning of	Maximum or minimum elevation.	Elevation at end of period.	Tidal area, million sq. ft.	Tidal prism volume, million sq. ft.	Total volume at end of period, million cu. ft.
P-Arthur Kill	Flood	+1.5	4.1	2.35	123.34	289.9	2,263.4
P′ " "	Ebb	+2.35	0.0	1.50	123.34	185.0	2,158.5

Let M = clean water from the Lower Bay
Let K = water received from the Kill von Kull or Newark Bay
Let n = tide under consideration, flood or ebb
n-1 = the previous tide, ebb or flood
Then P_n = 2,263.4 million cu. ft. = 1,839 5 million cu. ft. (P'_{n-1}) + 423.9 million cu. ft. (M) = 8 28% (P'_{n-1}) + 18.72% (M)
= .8522 P'_{n-1} + 423 9 million cu. ft. (M)
P'_n = 2,158.5 million cu. ft. = 839.5 million cu. ft. (P_{n-1}) + 319.0 million cu. ft. (K) = 85.22% (P_{n-1}) + 14.78% (K) = .8128 P_{n-1} + 31.80 million cu. ft. (K)

*See map of Richmond Drainage District following p. 182.

80 Under present conditions it is estimated that the amount of sewage emptied into Arthur Kill amounts to 18.5 million gallons in 24 hours or 0.623 million cubic feet in 6 hours. Using this value in the above formulæ we get the following approximate figures for summer conditions:

Area.	Dilution ratio.	Per cent. of oxygen present. Without reaeration.	With reaeration.
P	1 in 127	76.5	86.9
P'	1 in 105	71.5	72.0

If the sewage from the Borough of Richmond be added to the sewage now discharged into the Kill from New Jersey, the figures will be as follows:

Area.	Dilution ratio.	Per cent. of oxygen present. Without reaeration.	With reaeration.
P	1 in 98	69.4	69.9
P'	1 in 76	60.6	61.1

The waters of the Upper Bay are so intimately connected by circulation with the waters of the Hudson and East Rivers that no increased pollution there is permissible. The Lower Bay, however, has its tidal prism filled and emptied in each tidal period from and into the waters of the ocean and has a capacity for sewage reduction greater than is necessary for all of the areas of its drainage basin. The safe points for the discharge of unpurified sewage from Staten Island are then into the deep channel of the Narrows and into the Lower Bay at those points lying near the channels of the bay through which the circulation of its waters takes place, including the lower half of the coast line between Great Kills and the southern end of the island.

The configuration of the land in Staten Island is not such as to render the concentration of the sewage and its discharge at the points named a simple matter. The natural drainage is to the east into the Lower Bay and to north and west into the Kill von Kull and the Arthur Kill. The divide between the two watersheds is a bold ridge. At the north it rises abruptly from the water to a height of 200 feet opposite the entrance to the Kill von Kull. From this point it runs slightly west and south with steep side slopes and gradually increasing elevation until about 4 miles from its northern extremely it attains a height of over 400 feet. It then inclines to the southwest and two miles further on drops to a height of 50 feet and gradually rises again to an average height of 100 feet, terminating near the south part of the island. The gap mentioned above affords a means of leading the drainage from a large part of the north watershed into the Lower Bay without the necessity for expensive tunnelling.

81 Along the Arthur Kill there are extensive areas lying at an elevation of less than 10 feet above mean sea level, which must

be drained into the Arthur Kill, unless expensive pumping plants are installed. The general configuration of the north watershed is such that an economical design will require minor lifts and long trunk lines, so as to permit of sewer discharge without purification, but the drainage system as projected has been designed with a view to a minimum expense for installation and operation.

The future population has been estimated at 25 per acre; the volume of sewage at 125 gallons per capita; ground water flow is assumed to be 0.003 second-feet per acre; other assumptions are similar to those of the other districts.

Seven outfalls are projected. The first serves the north and northeast shores and discharges into the deep water of the Narrows near the Quarantine Station. The second serves the area to the west of the ridge lying above the 50-foot contours and also the area east of the ridge above the 40-foot contours between the Narrows on the north and Great Kills on the south. The third serves the low land about Great Kills and discharges off shore in 12 feet of water by means of a pressure main.

The fourth serves the eastern slope of the ridge between Great Kills and Princes Bay and discharges 800 feet off Seguine's Point at the head of Princes Bay in a 21-foot channel running parallel to the shore. The fifth serves the south end of the island and discharges 1,600 feet off shore below Princes Bay into the same channel. A portion of the sewage discharged here will have to be pumped over the ridge whence it will discharge by gravity and another portion will have to be lifted from a sump to the gravity discharge main.

No purification will be required for the sewage discharged from these five outfalls.

The two areas of low land along the Arthur Kill will have to be provided with distinct systems, each concentrating in a sump, from which the sewage must be lifted and after partial purification, discharged into the Arthur Kill. Complete purification will be unnecessary, since once the waters have reached the Lower Bay there will be ample capacity there to receive and care for the sewage carried by them.

Full details of the system as projected are contained in the special report dated February 15, 1911.

Bronx District Sewage—Since the drainage from this district can be carried to the East River at points near Throgs Neck, where the capacity of the waters is ample to care for it without purification, it has not been deemed necessary in the limited time at our disposal to do more than indicate the possible points of concentration and discharge.

The drainage lines recommended for all of the districts are shown on the accompanying map.

82 **Chapter V.**

In making the studies reported in the preceding chapters, the lack of means to obtain more accurate maps of the districts reported on, more complete data as to the volume of sewage now being discharged into the various parts of the harbor, greater detailed knowledge of current velocities and a more complete set of determinations of the average existing pollution were keenly felt by the authors. They feel confident, however, that true conclusions can be derived from the work accomplished.

Table 6 in Chapter I shows clearly how pollution in one part of the harbor affects the remaining areas. At the end of the flood current period the Hudson below Ninety-sixth street is filled by waters of which 3 per cent were in the Lower Bay at the end of the last ebb and 97 per cent in the Upper Bay at the same tidal period; the Hudson between Ninety-sixth street and Spuyten Duyvil received 17 per cent of its contents from waters of the Upper Bay of the preceding ebb and 83 per cent from below Ninety-sixth street; the East River, from the Battery to Hell Gate, is filled with the waters of the Upper Bay of the last ebb tidal period; the waters of the East River beyond Hell Gate are 7 per cent from the Upper Bay of the preceding ebb, 41 per cent from the lower East River of the preceding ebb, 50 per cent from its own waters of the preceding ebb and 2 per cent from the Harlem of the preceding ebb; and the Harlem is made up 25 per cent from its own waters of the preceding ebb, and 75 per cent from the waters of the Hudson of the same period. During this period the flow has been from Sandy Hook toward Throgs Neck, via the East River direct and via the Hudson, Harlem and East Rivers; the clean sea water entering but for a short distance, the remainder of the flow being composed of water more or less polluted from its earlier stay in the harbor.

During the ebb period the flow is in the opposite direction. Pure water enters from the Sound and penetrates but a short distance into the East River. Thus at the end of the period it is seen that only 20 per cent of the volume east of Hell Gate is pure, the remainder being of water which has been in the area for from 6 to 12 hours longer; the Harlem contains 65 per cent of water from the earlier East River flood and 35 per cent from its own preceding flood volume; the Hudson above Ninety-sixth street is composed 81 per cent of water which had been in it in the second preceding ebb, 3 per cent of Harlem water of the preceding flood and 16 per cent of water from the Hudson above Spuyten Duyvil; below Ninety-sixth street the waters are 25 per cent preceding ebb, 14 per cent from the Hudson above of the preceding ebb and 60 per cent of those of the preceding flood plus 1 per cent of Harlem water of the preceding flood; the Upper Bay is a mixture from the Hudson and East Rivers and from the Kill von Kull.

The resultant movement of the circulation is towards Sandy Hook, but this movement is not continuous nor at a fixed rate (the formulæ being based on mean tidal conditions). During all of the time of fluctuation through the various channels each cubic foot of water

is giving up oxygen in sewage reduction, with no accessions save the small amount received by reaeration.

A study of Table 9 shows the danger of continuing longer the present system of conveying sewage to the nearest waterway
83 and there discharging it without treatment. Tables 9, 10 and 11 show that, while the capacity of the harbor waters to receive and reduce sewage without undue pollution is ample for the present population, such is the case only when the sewage is discharged near the harbor entrances; and further that even with full diffusion, it is unsafe to discharge sewage into the river waters without treatment. Either conveyance to the harbor entrances or treatment before discharge is feasible, but either course would entail a heavy expenditure. The selection of the more economical can not be made without further and detailed investigation.

The effect of the pollution of the Hudson River above the limits of the City on the waters of the upper Hudson and the Harlem is shown clearly in the formulæ of Table 6, and in the oxygen percentages of Tables 9 and 10. Table 10 shows that were it not for the pollution of the Hudson above the city limits, the average oxygen contents of all of the harbor waters would be made over 60 per cent. of saturation by partial purification of the sewage now discharged into the Hudson and Harlem Rivers alone. Table 11 shows this even more forcibly.

The investigations into the method of partially purifying the sewage by aeration, described in detail in Chapter III, show the possibility of obtaining at small cost and with a plant requiring little space a degree of purification ample for sewage emptying into waters under conditions similar to those of Jamaica Bay and of the Arthur Kill. The authors feel sufficient confidence in the results obtained to warrant them in recommending that the existing Twenty-sixth Ward Pumping Station in Brooklyn be fitted with a plant for sewage treatment by this method, with the belief that with greater experience the method can be further developed, so as to warrant a more extended application.

The studies of the harbor capacity warrant them further in recommending that no purification be now made of sewage from the Flushing, Corona and Bronx Districts discharged into the deep water of the channels of the East River at points east of Riker's Island.

In order to avoid a local nuisance, from such discharge, it is necessary that a complete diffusion of the sewage be made immediately on discharge. They know of no method now in use which will secure such diffusion and recommend that experimental work be carried on to develop the best form of outlet for this purpose.

Finally, they would state that it is their belief that radical measures are now necessary for the prevention of injury to the harbor by sewage pollution. Since to be effectual such measures must be applicable to all communities from which sewage is discharged, they believe that joint action in the matter is necessary by the States of New York and New Jersey; that a standard of purity should be adopted for the harbor waters; that the measures necessary to attain

and maintain that standard should be determined; and that such further action as may be necessary to carry such measures into effect should be taken.

Respectfully submitted,

W. M. BLACK.
EARLE B. PHELPS.

New York, February 16, 1911.

84 *Appendix.*

Determination of the Rate of Absorption of Atmospheric Oxygen by Water.

In the text of this report brief reference was made to the relationship existing between time, depth and initial degree of aeration and the amount of atmospheric oxygen absorbed by a given body of water. The mathematical derivation of these relationships and the technique involved in the experimental determination of the diffusion coefficient will be given here in full.

Mathematical.

Assume a column of water, not fully saturated with dissolved oxygen, and exposed to the atmosphere at one end. This is essentially the condition found in a lake.

An infinitely thin layer at the surface of the water becomes saturated with oxygen in an infinitely short time, i. e., at once. This layer can absorb no more oxygen until a portion of that which it contains has passed, by diffusion, to the deeper layers. The rate of absorption therefore is governed wholly by the rate at which oxygen diffuses through the liquid.

The diffusion law:

Fick's law of hydro-diffusion (Nernst, Theoretische Chemie, 2nd German Ed., p. 150) expresses the rate of diffusion of dissolved substances in terms of the concentration gradient as follows:

$$\frac{ds}{dt} = -aq \times \frac{dc}{dx}$$

ds is the amount of substance passing any point, x, through a cross-sectional area, q, in time, dt, when the concentration gradient is $\frac{dc}{dx}$; c is the concentration at any point, varying with x, and a, is a constant for the given substance at given temperature called the coefficient of diffusion.

The first problem is to derive from the fundamental equation an expression which will permit the experimental determination of "a."

At the point x + dx the concentration gradient becomes

$$\frac{dc}{dx} + \frac{d}{dx}\left(\frac{dc}{dx}\right) dx = \frac{dc}{dx} + \frac{d^2c}{dx^2} \cdot dx$$

and the amount of substance passing that point is determined by

$$\frac{ds}{dt} = aq\left(\frac{dc}{dx} + \frac{d^2c}{dx^2} \cdot dx\right)$$

The difference between the amount passing point x and that passing point x + dx is the increase in the amount of substance present in the volume qdx during the time dt. This is

$$aq \frac{d^2c}{dx^2} \cdot dx$$

85 The increase in concentration in this section is the increase in amount divided by the volume, or

$$\frac{dc}{dt} = \frac{d^2c}{dx^2}$$

which states that the rate of change in concentration of dissolved substance occurring at any point, x, is proportional to the differential of the concentration gradient or the second differential of the concentration itself with respect to the distance. If the gradient be uniform, differential zero, there is no change in concentration occurring at any point.

It will be convenient to express concentration in the usual form, milligrams per liter, or parts per million, distances in centimeters and time in hours which will result in giving the constant "a" a fixed value. As thus defined, "a," the diffusion coefficient, is the rate per hour at which the concentration of dissolved substance is changing at any instant, under the condition that the concentration gradient is changing at a rate of one milligram per liter, per centimeter *per centimeter*.

The relations are almost exactly those existing in the case of the transfer of heat through a conductor.

The solution of the differential equation given above requires the establishment of certain limiting conditions, although the equation itself applies to all conditions.

Case I.

The water contains no oxygen at the start. A surface film becomes saturated instantly, concentration, s. The column has a definite length (L).

to solve $$\frac{dc}{dt} = a \frac{d^2c}{dx^2} \qquad (1)$$

Under the given conditions when

$$t = o \qquad c = o \qquad (2)$$
$$x = o \qquad c = s \qquad (3)$$
$$x = L \qquad \frac{dc}{dx} = o \qquad (4)$$

The reason for applying condition (4) requires discussion. Since no oxygen is passing the closed end, the gradient obviously becomes zero at that point, after the oxygen has diffused to the end of the column. But mathematically a gradient of zero at $x = L$ implies a positive gradient at all other values of x less than L, which in turn implies some oxygen at all points from the start, or, in other words, an infinite rate of diffusion for the first diffusing molecule. This conception could only be realized if the diffusing gas itself were infinitely divisible. At concentrations with which we deal analytically matter is practically divisible in this way and the inconsistency vanishes. After deriving the experimental constants involved it will be possible to calculate the actual magnitude of the inconsistency noted.

A general solution of equation (1) is

$$c = -e^{-ab^2t} \sin bx + \text{const.}$$

or any multiple of such a term or the sum of any series of such terms.

Substituting condition (3) we have

$$\text{const.} = S$$

Giving

$$c = -\epsilon^{-ab^2t} \sin bx + S$$

Differentiating and substituting condition (4) we obtain

$$\frac{dc}{dx} = -\epsilon^{-ab^2t} \cdot b \cdot \cos bL = o$$

which is true if

$$b = \frac{(2\eta + 1)\pi}{2L}, \ \eta \text{ being any positive integer.}$$

Finally to satisfy condition (2) we have

$$S = \sin bx$$

Since the general solution given above may contain a series of terms of the same form as the one developed, Fourier's series is available for determining this function.

We may write

$$S = \frac{4}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} \sin \cdot (2\eta + 1)\, y \text{ by Fourier's series.}$$

Put $y = \frac{\pi x}{2L}$, and the expression, $\frac{2\eta+1}{2L} = b$,

$$S = \frac{4}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} \sin \cdot bx$$

Since this expression is the sum of a series of multiples of sin bx, it may be substituted for sin bx in the general solution. Making all substitutions:

$$c = s - \frac{4}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} \cdot \epsilon^{-ab^2t} \cdot \sin bx$$

when $b = \frac{2\eta+1}{2L}$, η being any integer.

This equation expresses the relation existing between concentration of dissolved oxygen at any point, (c), distance of that point from the exposed surface, (x), and time of exposure, (t). With a fixed time it is the equation of the concentration curve, giving concentrations at all points from surface to bottom. Experimentally we can best determine the average concentration in the column. The determination of a concentration at any given depth

4085

DARK PAGE BLEED THRU

would be analytically difficult. We may, therefore, determine from this equation the total amount of oxygen contained in a given differential volume and by the summation of all these amounts arrive at an expression for the total amount of oxygen in the column.

Let the area of the cross section of the column be q. The volume of a differentia strip will then be q dx. The amount of oxygen in this volume is the concentration times the volume or

$$dO = cqdx = Sqdx - \frac{4\,Sq}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} e^{ab^2t} \sin bx \cdot dx$$

We may now obtain the total amount of oxygen in the column by integrating this equation between limits, o and L;

$$O = Sq \int_L^o dx - \frac{4\,Sq}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} \cdot e^{-ab^2t} \int_L^o \sin bx \cdot dx$$

$$= SqL - \frac{4\,Sq}{\pi} \sum_{\eta=\infty}^{\eta=0} \frac{1}{2\eta+1} \cdot e^{-ab^2t} \cdot \frac{1}{b}$$

Substituting the value of $\frac{1}{b}$ and simplifying

$$O = SqL\left(1 - \frac{8}{\pi^2} \sum_{\eta=\infty}^{\eta=0} \frac{1}{(2\eta+1)^2} \cdot e^{-ab^2t}\right)$$

But SqL represents a condition of saturation in the volume qL, so we may express the oxygen in terms of "per cent. saturation" by dividing by the saturation value, SqL, and multiplying by 100.

$$O\ (\%\ Sat) = 100 - \frac{800}{\pi^2} \sum_{\eta=\infty}^{\eta=0} \frac{1}{(2\eta+1)^2} e^{-ab^2t}$$

Whence we derive as a working formula

$$D.\ O. = 100 - \left(81.06\, e^{-K} + 9.007\, e^{-9K} + 3.242\, e^{-25K} + 1.654\, e^{-49K} - - - -\right)$$

In which $K = \frac{a\,t\,\pi^2}{4\,L^2} = \frac{2.467\,a\,t}{L^2}$

e = 2.718, base of natural logs.
a = diffusion coefficient (to be determined).
t = time in hours.
L = length of column in centimeters.

Case II.

Similar to I. except that the concentration at the start is B, throughout.

To solve

$$\frac{dc}{dt} = -\frac{d^2c}{dx^2} \qquad (1)$$

Under the conditions

When $t = o$ $\quad c = B$ (2)

$x = o$ $\quad c = S$ (3)

$x = L$ $\quad \frac{dc}{dx} = o$ (4)

The procedure is exactly the same as in I. until condition (2) is treated. Here we get

$$S - B = \sin bx$$

When the final equation becomes

$$C = S - \frac{4(S-B)}{\pi} \sum_{\eta=\infty}^{\eta=o} \frac{1}{2\eta+1} \cdot e^{-ab^2t} \sin bx$$

This equation is integrated in the same way, giving

$$O = SqL - \frac{4(S-B)q}{\pi} \sum_{\eta=\infty}^{\eta=o} \frac{1}{2\eta+1} e^{-ab^2t} \cdot \frac{1}{b}$$

Whence the final working formula becomes

$$O(\%\text{ sat.}) = 100 - \left(1 - \frac{B}{100}\right) \cdot (81.06\, e^{-K} + 9.007\, e^{-9K} + 3.242\, e^{-25K} + 1.654\, e^{-49K} - - -)$$

$$= 100\left[\left(\left(1 - \frac{B}{100}\right) \cdot 81.06 \cdot \left(0.779 + \frac{0.105}{9}e^{-K} + \frac{0.0019}{25}e^{-K} - - -\right)\right)\right]$$

B = initial value of dissolved oxygen.

D = final value of dissolved oxygen.

K = a constant for each experiment $= \frac{\pi^2 a t}{L^2}$

t = time in hours.

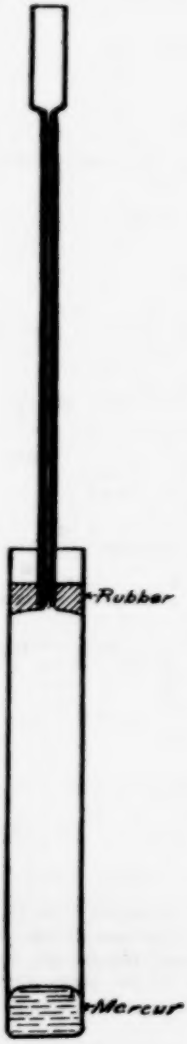
L = depth in centimeters.

a = diffusion co-efficient.

The determination of K from this equation, with O, S and B given is not possible by any workable method. The sum of the series was therefore determined with varying values of K and the results plotted. It was observed that by plotting the logarithms of the sums against corresponding

Apparatus
Used in Determining
Diffusion Coefficient.

Diagram I
(Appendix)



76—Ex. 136

The determination of K from this equation, with O, S and B given is not possible by any workable method. The sum of the series was therefore determined with varying values of K and the results plotted. It was observed that by plotting the logarithms of the
90 sums against corresponding values of K the result was nearly a straight line for the higher values. This method of plotting was therefore employed. This line deviates from a straight line more and more in the lower values when the solution requires a greater number of terms of series. Forty terms of the series were employed in the computation at K=.0001. In the range over which the plot will be of greatest practical value, the determinations are quite accurate and interpolations can be satisfactorily made.

Experimental.

The experimental determination of a is now made possible. If a column of water, whose initial content of oxygen is known, be exposed to the air for a definite time and the final content of oxygen be then determined, data are available for calculating the coefficient a. It is essential that during the test there shall be no circulation of the water within the tube. The rate of absorption is so slow that results of maximum accuracy are obtainable only in tubes of short length, exposed for a few hours. Lengths of 7 to 8 centimeters were found most satisfactory. To test the depth factor, L, in the formula a few determinations were made in tubes of four centimeters. The determination of dissolved oxygen in such small volumes required more delicate methods than those in common use. The method which was finally adopted is the result of a long investigation of possible methods. It depends upon the reoxidation of decolorized indigo.

A detailed description of the method employed is as follows: A quantity of "iron-excelsior," made of fine iron turnings was placed in a flask of water which was then vigorously boiled. After boiling for some time the flask was connected with a hydrogen generator through an absorption bottle containing pyrogallate solution, and the flame was removed. The flask was allowed to cool in this condition over night. The next morning water could be drawn which contained three to ten per cent. of the saturation value of dissolved oxygen. Water with less oxygen than this is exceedingly difficult to prepare.

The apparatus employed for the determination of absorption is shown in the sketch. It consisted of a test tube, into which a rubber stopper was fitted with extreme care, so as to slide plunger-fashion within the tube. This stopper was wet with a very dilute caustic solution to assist the sliding. The capillary glass tube passed through the stopper to its inner surface which was concaved slightly. The tube was expanded at its upper end into a straight-sided funnel. Two etched lines, one near each end of the tube, marked off a definite volume.

The tube was filled with mercury to slightly above the lower line. The stopper was then forced into the mercury, expelling all air and forcing mercury through the capillary to the upper funnel. A si-

phon from the bottom of the flask described above was then inserted into the funnel, its end projecting below the mercury, and the water was allowed to run for a minute or two, overflowing from the funnel. Then while the water was still running, and overflowing, the stopper was slowly withdrawn, allowing a small stream of water to enter the tube. In this way the water was transferred without contact with the air.

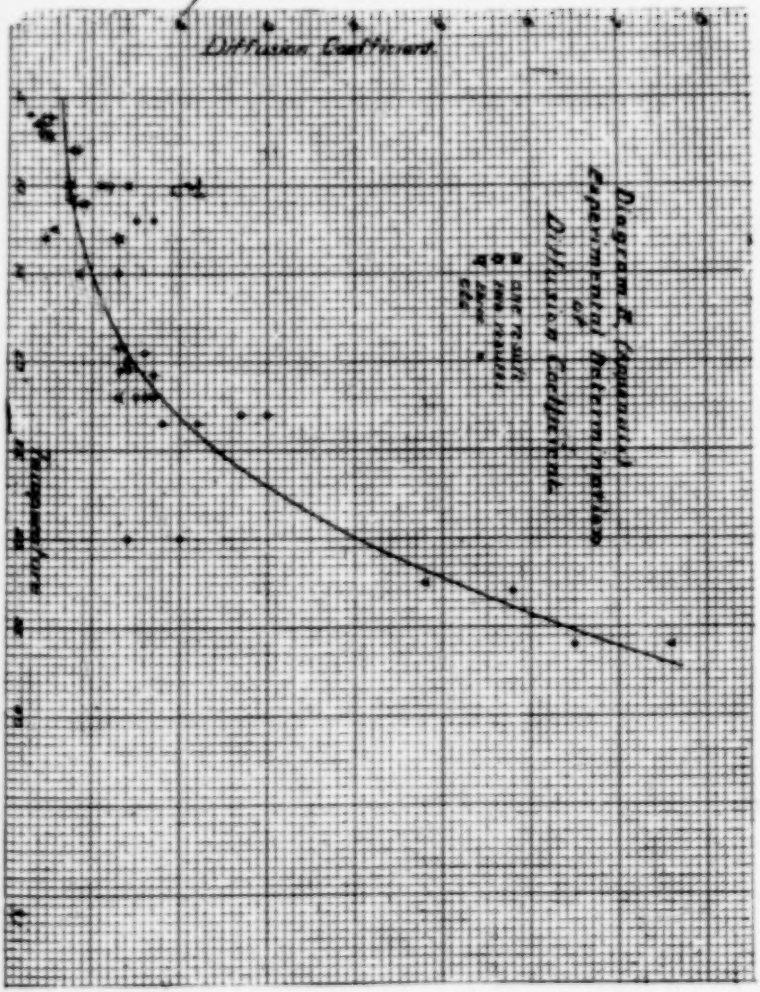
When the stopper had reached the upper mark, its movement was stopped and, while the water was still flowing above, a drop of
91 mercury was added to the funnel to seal the capillary. The tube was then removed, the funnel emptied of water and dried and the whole apparatus set in a large water tank, previously brought to the temperature desired for the experiment.

The tube was left there one hour to acquire a uniform temperature. Then while still immersed nearly to its upper edge, the tube was exposed to the air by the removal of the stopper and capillary. The time was noted and during the exposure the oxygen in a set of "blank" tubes was determined. These blanks were prepared exactly as described here, but were not exposed. They furnished the initial value, B, in the formula.

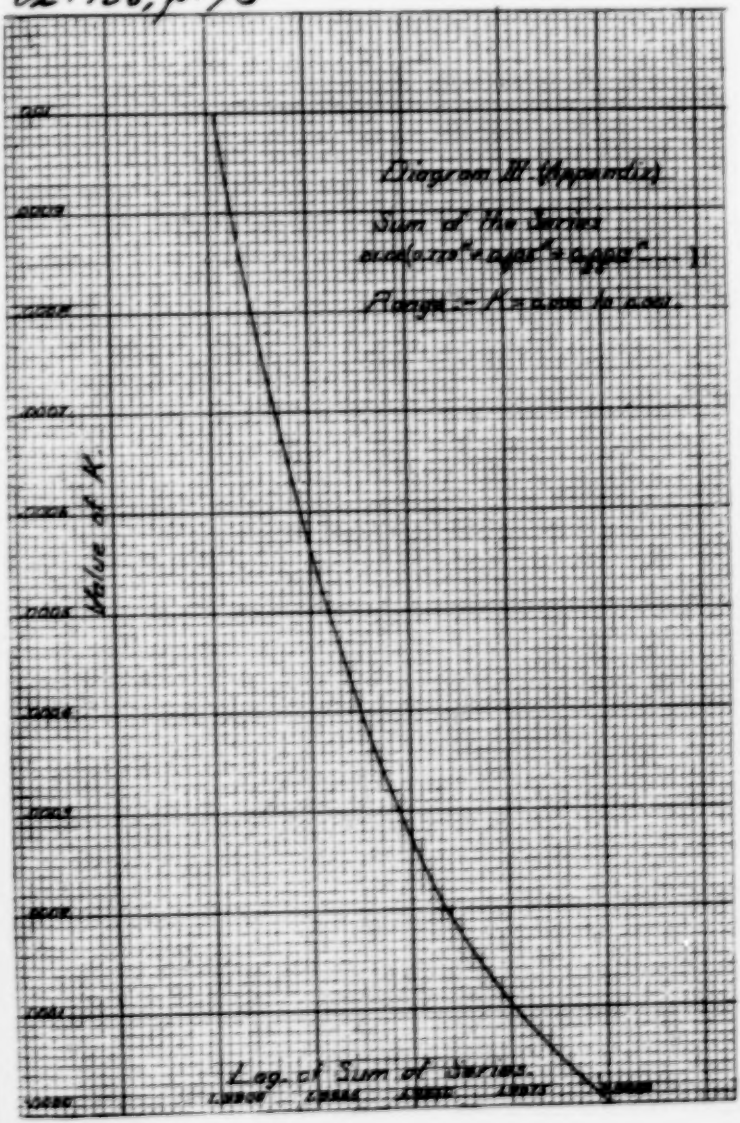
After an exposure of from one-half to four hours the tubes were again plugged with the same stoppers and capillaries, the stopper being forced in until the capillary was filled and a seal of mercury was applied as before. The tube was now ready for an oxygen determination.

A solution of indigotine or soluble indigo was placed in the funnel, above the mercury seal. A solution of sodium hydro-sulphide was added in excess to completely reduce and decolorize the indigo. A glass tube connected with a carbon-dioxide generator was inserted into the funnel and a stream of carbon-dioxide blown through the reduced indigo. This gas, by accumulating over the liquid prevented the too rapid oxidation of the indigo by the air, at the same time there was enough oxygen in the carbon-dioxide to oxidize the indigo slowly and uniformly. Finally a faint blue color would return in the tube and when this color matched a standard tube which had been prepared of known value, the stopper was raised and the indigo added to the water. A new mercury seal was put in, the tube well mixed and put aside. The oxidation of the indigo was almost instantaneous but proceeded at a decreasing rate for some time. While still sealed from the air this tube was then compared with a set of standards in similar tubes, the latter having been prepared by diluting a standard indigo solution which was made up to match a single test made upon a saturated water of known oxygen content. Repeated tests of this method upon waters of known value showed that it could be relied upon to give results with these small amounts of water, that were free from reagent corrections and of much greater accuracy than could be had from the older method.

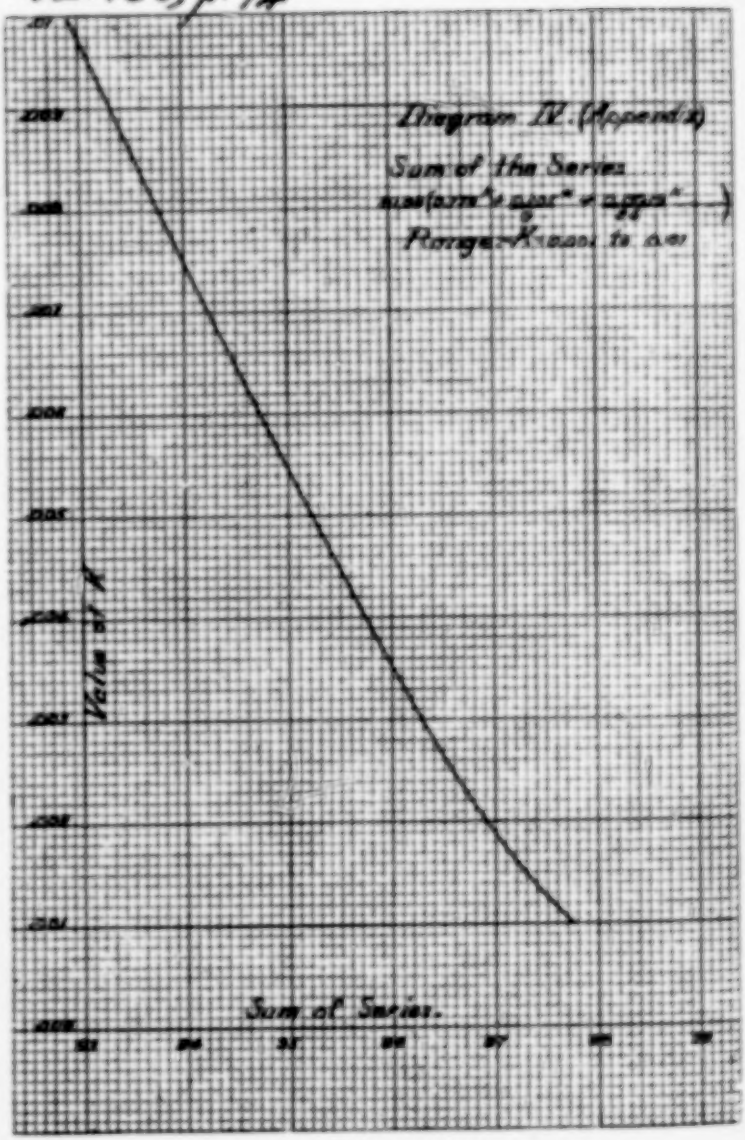
Ex. 136-p. 92



Ex. 136, p. 93


Diagram III (Appendix)
Sum of the Series
Value of K
Log. of Sum of Series.

Ex. 136, f. 94


Diagram IV. (Appendix)
Sum of the Series
Value of N
Sum of N Series.

Results.

One hundred and fourteen tests were made at temperatures ranging from 6 degrees to 30 degrees, with tube lengths of from 3.8 to 8.4 centimeters and with exposures of from one-fourth to four hours. The results have been plotted in Diagram II., values of a being shown in relation to temperature. To avoid confusion, sets of closely agreeing results have been averaged and the average values shown as one value, the number of determinations included in the average being indicated by the number of radial lines about the circle. The values are somewhat scattering, and a closer analysis indicates that some unknown factor is involved. Exceedingly concordant results are readily obtained upon any one day, while upon the following day another group of concordant results will be obtained differing from the first. Barometric corrections were later applied without
91½ relieving the situation. It is quite likely that humidity conditions would explain the irregularities. Considering the variations in depth, time, and initial values, that were employed the results on the whole are satisfactorily uniform and the curve which has been drawn, being deduced from such a large number of results, probably gives a value of the diffusion coefficient at any temperature which is not far from the actual truth.

Within the range of values which have been employed in the computations in the text errors resulting from the maximum divergence of individual tests from the average value of the curve are less than 5 per cent. at the five-foot depths and less than 2 per cent. at the twenty-foot depths.

(Here follow diagrams II, III, and IV, marked pages 92, 93, and 94, Complainants' Exhibit 136.)

95 *Special Report on the Corona Drainage District Submitted to the Board of Estimate and Apportionment June 17, 1910.*

96 CHIEF ENGINEER'S OFFICE,
BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, June 10, 1910.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment.

SIR: Herewith is transmitted a report from Colonel William M. Black and Professor Earle B. Phelps, bearing date of May 24, 1910, relative to the treatment of the drainage of that portion of the Borough of Queens north of the ridge or backbone of the island, and extending from Flushing Creek to Newtown Creek.

The investigation of the matter of reference has been made pursuant to the authorization of the Board of November 12, 1909, under which Colonel Black was engaged to advise relative to the treatment of the drainage problem of the city in so far as it related to the pollution of the adjacent waters.

The result of the investigation of this problem for the territory between Flushing Creek and Little Neck Bay was made the subject of a report which was presented at the Board meeting of April 22, 1910, and which was thereupon referred to the President of the Borough of Queens for general guidance in the design of sewers for the locality. At this time attention was called to the fact that to establish its feasibility the plan submitted had been made to include a general subdivision of the territory considered into drainage districts and also the planning of the main trunk lines, but that the latter was based on making provision only for the sanitary flow with which the investigation was primarily concerned. It was suggested at this time that it would seem desirable to provide in the drainage plan for the removal of both the sanitary and storm water flow in a combined system of sewers, and that if such treatment were to be adopted it would probably be necessary to modify the plan in many particulars, although it was believed that the general scheme could be applied.

The report now presented relates to an area of about 14,535 acres, for which the sanitary requirements only have been considered other than in so far as an excess of capacity may have been provided to meet future growth and which may, for a limited time, be utilized for removing the surface water.

In general, the plan contemplates two main trunk sewers, these providing, respectively, for the independent drainage of most of the First and Second Wards, these sewers meeting at the junction of Riker avenue and Theodore street, from which point the main outlet would extend out to deep water off the foot of the latter street. This outlet is stated in the report to have been selected, having in view the possibility of extending it by tunnel to Rikers Island in case it should be ultimately found necessary to install purification works.

It has not been found practicable to incorporate in the plan that

97 portion of Long Island City immediately adjoining the water front and an area of considerable extent at the head of Newtown Creek, both of which are at such low elevation as to require pumping. The sewers in the former section have been largely constructed and it is evidently believed that their use can be continued for some time in the future. It is also understood that a portion of the low area may possibly find an outlet through sewers in the Borough of Brooklyn. A small area in the vicinity of Bowery Bay is also found to be of too low an elevation to secure a gravity outlet, but in the remaining subdivisions of the drainage area it is understood that no pumping will be required.

A number of sewers have already been built in the Elmhurst section, and the plan makes provision not only for continuing their use but also that of the purification plant already built until such time as it is found practicable to carry out what is suggested as the ultimate plan.

In the report it is pointed out that the studies relative to the capacity of the harbor to absorb sewage are still in progress and have not yet advanced far enough to warrant any recommendation in the matter. Attention, however, is called to the desirability of supplementing this work with independent investigation and experiment at various points which would bring out information not now available relative to the requirements which must be met before reaching a final determination as to the extent of the purification which will undoubtedly at some time be required.

I would recommend that a copy of this report be sent to the Presidents of the Boroughs of Brooklyn and Queens to be used for their guidance in the development of the drainage plan for the territory affected.

Respectfully,

NELSON P. LEWIS,
Chief Engineer

98

May 24, 1910.

Mr. Nelson P. Lewis, Chief Engineer Board of Estimate and Apportionment.

SIR: In connection with our general studies of the sewerage problems of certain portions of Greater New York, we beg to submit herewith a second report, which deals with the main drainage problem of that portion of Queens Borough lying between Flushing Bay, Newtown Creek, the East River, and the division line between Queens and Brooklyn. For purposes of convenience and identification we have designated this district the "Corona Drainage District." Reference to the accompanying map marked "Corona Drainage District"* will facilitate the discussion which follows.

*Omitted. See general map of Drainage Districts of Jamaica, Corona, Flushing, and Westchester, p. 148.

Divisions of the Drainage District.

For the purposes of this study we have divided the above designated district into eighteen drainage areas, numbered respectively 1 to 18, of which areas Nos. 3, 4, 5, 9, 10 and 11 are subdivided into two sub-areas designated by *a* and *b* respectively; and areas Nos. 6, 8 and 13 are similarly subdivided by *a*, *b* and *c* respectively. In the map the division lines between these areas are indicated by heavy dotted lines. Contour lines at 20-foot intervals are shown, but these are only approximate, by reason of the lack of detailed topographic surveys and of available time and funds for making such surveys, which has been commented upon in our first report. Our proposed sewer lines are indicated in red, and other features are sufficiently described in the legend. Estimates of future populations have been made upon a basis of either twenty-five or fifty persons per acre, depending upon the location of the area in question and the character of the country. The drainage areas dealt with are approximately as follows:

Area No. 1. This area is bounded on the south by a crest line which is practically the division line between two wards; it extends on the east to a crest line which has already been identified as the westerly boundary of the low level area in the Flushing Drainage District, and on the north to a crest which parallels the first crest mentioned for a distance of about seven thousand feet. Its westerly boundary is a broken line which has been determined by the requirements of existing sewer assessment districts. It contains 2,343 acres, from which we have deducted 793 acres of parks and cemetery land. The estimated future population is 38,750.

Area No. 2. This is a small area lying between the northerly boundary of No. 1 and the 20-foot contour line which separates it from the low level area of the Flushing Drainage District. It extends on the west to Dry Harbor road. It contains 482 acres, with an estimated future population of 24,100.

Area No. 3. This is a small area bounded practically by Metropolitan avenue, Dry Harbor road and North Hempstead Plank road on the south, east and north, respectively, and on the west by the natural crest line as indicated. It contains 500 acres, with an estimated future population of 25,000. It is subdivided into two subareas of 360 and 140 acres with 18,000 and 7,000 estimated future populations, respectively.

Area No. 4. This area lies to the north of No. 3 and extends to Woodside and Broadway on the north, and to Dry Harbor road on the east. Its westerly boundary is a crest line just west of Fiske avenue. It is further divided by a crest line running northeast, as shown. It contains 613 acres, with an estimated future population of 30,650, of which 266 acres and 13,300 population are included in Sub-area *a*, and 347 acres and 17,350 population are included in Sub-area *b*.

99

Area No. 5. This area lies to the northwest of the low level area of the Flushing District already described, and above the 20-foot contour line. It extends on the north to Jackson avenue and on the

west to a crest line running north and south as shown. It is subdivided as shown. It contains almost all the Corona section, having a total area of 959 acres, with an estimated future population of 47,950, of which 761 acres and 38,050 population are included in sub-area *a*, and 198 acres and 9,900 population are included in sub-area *b*.

Area No. 6. This area lies to the northwest of No. 5, extending to Flushing Bay on the northeast and following the 20-foot contour line on the northwest. It extends on the west to a crest as shown and on the south to Woodside. It is subdivided into three sub-areas: Sub-area *a* comprising the southeasterly half of the whole area; *c* comprising a strip about 1,500 feet in width along Flushing Bay; and *b* the remainder. It contains altogether 1,154 acres with an estimated future population of 57,700, of which 610, 359 and 185 acres, and 30,500, 17,950 and 9,250 population are included in sub-areas *a*, *b* and *c*, respectively.

Area No. 7. This area is a narrow winding low-level strip lying to the northwest of No. 6, situated entirely below the 20-foot contour line. It comprises practically the low land surrounding the small inlet from Flushing Bay to the southeast of Sanford Point. It contains 381 acres, with an estimated future population of 19,050.

Area No. 8. This area is a similar narrow strip lying to the northwest of No. 7, extending to the waterfront on its easterly end and to a crest which is practically a projection of this same waterfront as far west as Wilson avenue. It includes also a larger area to the west of Nos. 6 and 7, bounded practically by Newtown road and Woodside. It is subdivided into three sub-areas. It contains 811 acres, with an estimated future population of 40,550, of which 569, 126 and 116 acres and 28,450, 6,300 and 5,800 population are included in sub-areas *a*, *b* and *c*, respectively.

Area No. 9. This area lies to the northeast of No. 8 and is bounded on the east by the 20-foot contour which practically parallels Winthrop avenue, and on the west by crest line which follows Ditmars avenue closely. It extends on the north practically to the East River. It is subdivided into two sub-areas and contains 403 acres, with an estimated future population of 20,150, of which 207 and 196 acres, and 10,350 and 9,800 population are included in sub-areas *a* and *b*, respectively.

Area No. 10. This is a low-level area lying entirely below the 20-foot contour. It extends from Area No. 9 to the East River and includes on the east a narrow strip of shore front extending to Sanford Point; on the west a similar strip extending as far as Astoria. It is subdivided into two sub-areas. It contains 394 acres, with an estimated future population of 19,700, of which 197 acres and 9,850 population are included in each of the sub-acreas.

100 Area No. 11. This area lies to the southwest of No. 9 and in part to the north of No. 8. It extends also to the west in a narrow point to Noble avenue in the Ravenswood district. It is bounded on the northwest by the 20-foot contour, which separates it from No. 10, and by a straight line which is practically identical

with a continuation of that contour between Astoria and Ravenswood. The westerly point is bounded on the south by a crest line as shown. It is subdivided into two sub-areas. It contains 966 acres, with an estimated future population of 48,300, of which 374 and 592 acres and 18,700 and 29,600 population are included in sub-areas *a* and *b*, respectively.

Area No. 12. This area includes the waterfront from Astoria south and west to Newtown Creek. It is bounded on the east by a line which follows in general the 20-foot contour. It contains a portion of Astoria and all of Ravenswood and Hunters Point, with an area of 129,000 acres and an estimated future population of 64,500.

Area No. 13. This area lies between Areas Nos. 8, 11 and 12 as defined, and extends on the southeast to the crest line which runs in a southerly direction from the junction of Greenpoint avenue and Woodside to Newtown Creek. It is subdivided into three sub-areas. It contains 1,209 acres (of which 167 comprise parks and cemeteries), with an estimated future population of 52,100, of which 511,382 and 316 acres, and 25,550, 19,100 and 7,450 population are included in the sub-areas *a*, *b* and *c*, respectively. The 167 acres of park and cemetery are within sub-area *c*.

Area No. 14. This area is a narrow strip lying to the southeast of Nos. 8 and 13. It extends on the east to Area No. 4 and on the south to a line which follows closely the 30-foot contour. It contains 335 acres, with an estimated future population of 16,750.

Area No. 15. This area lies to the southeast of No. 14, extends on the north and east to No. 4, on the west to the Long Island Railroad, and on the south to a line which practically marks the 35-foot contour. It contains 501 acres, with an estimated future population of 25,050.

Area No. 16. This area lies to the southeast of No. 15 and to the southwest of No. 3. It is bounded on the south by a crest line extending in an east and west direction as shown. It contains 909 acres of which 236 acres comprise parks and cemeteries, and its estimated future population is 33,650.

Area No. 17. This area comprises a narrow strip along the Newtown Creek and southwest of Areas Nos. 13 and 15. It is bounded on the south by a line which is practically identical with Grand avenue. It contains 255 acres, with an estimated future population of 12,750.

Area No. 18. This is a large area lying in the southerly corner of the drainage district. It extends from the Borough line on the southeast to the crests which have already been described as bounding Areas Nos. 1, 2 and 16.

The acreage and estimated future populations of these eighteen drainage areas are tabulated below. The total area of the district is 14,535 acres and the total estimated future population 628,200. This district as defined includes an area of 756 acres with an estimated future population of 37,800 (comprising areas 15 and 17), which is now, or will naturally become, tributary to the sewers of Brooklyn Borough.

101

Area.	Acres.	Poulation (est. future).
1	*1,550	38,750
2	482	24,100
3	500	25,000
4	613	30,650
5	959	47,950
6	1,154	57,700
7	381	19,050
8	811	40,550
9	403	20,150
10	394	19,700
11	966	48,300
12	1,290	64,500
13	*1,042	52,100
14	335	16,750
15	501	25,050
16	*673	33,650
17	255	12,750
18	1,030	51,500
	13,339	628,200
Park and cemetery	1,196	
Total	14,535	

* Includes park and cemetery land.

General Scheme of Sewerage for the District.

A general description of the scheme of sewerage which we have provided for the entire Corona Drainage District will now be given. The final point of discharge, as now provided, will be in deep water in the East River at a point approximately 1,500 feet to the southeast of Berrian's Island. The question of some form of treatment of this sewage will be considered in a later report. Having in mind the possibility that purification to some degree may be found desirable, this point of final discharge has been so located that if necessary the entire discharge can be carried by tunnel to Riker's Island, where suitable purification works can be installed. To bring the sewage to this point, we have provided two main intercepting systems which, for convenience, we will designate the East Interceptor and the West Interceptor. The main line of the East Interceptor may be considered to start at the junction of Myrtle and Tompkins avenues in Area No. 18, to flow in a westerly direction through that area to the Borough line, thence in a general northeasterly direction along the natural valley line which carries it eventually completely through the center of the district to a point on Flushing Bay, and thence following the shore to the point of discharge.

A main branch of this interceptor starts at nearly the same point

between Areas Nos. 1 and 18 and flows through a second valley in a northeasterly direction to the low land near Flushing Creek, thence on the margin of this low land to the point of junction with the main line in Area No. 5.

The West Interceptor may be considered to start at the extreme southern point of Area No. 13*c*, and to run in a general northerly direction to the Pennsylvania Railroad yards, making a de-
102 tour around these yards and thence northeasterly, following approximately the 40-foot contour to the north corner of Area No. 9*b*, and thence southeasterly to the point of discharge. Trunk sewers, designated in general by the number of the area served, will enter these interceptors as follows:

Trunk No. 3*a* enters the main branch where it crosses Trotting Course lane. This trunk is composed of two branches, draining the two sides of Sub-area No. 3*a*.

Trunk No. 3*b* enters this same branch near the point of crossing North Hempstead Plank road, and drains Areas 3*b*, 4*a* and 2.

Trunk No. 14 enters the East Interceptor at the corner of Maurice and Thompson and drains Area No. 14 and a portion of 4*b*.

Trunk No. 5*a* enters this same interceptor at Sycamore avenue and drains the northerly portion of Area No. 5*a*.

Trunk No. 5*b* enters this interceptor at Flushing and Newtown Turnpike, and drains Area No. 5*b*.

Trunk No. 6*b* enters this interceptor at the northern end of Area No. 6*c* and by its two branches drains Area No. 6*b*.

Trunk No. 7 enters the interceptor at the same point and drains Area No. 7. It will probably be necessary to pump from this trunk into the interceptor.

Trunk No. 8*b* enters the interceptor on the Shore road and drains directly Area No. 8*b*. It extends to the southwestern corner of Area No. 7, at which point branches draining Areas Nos. 8*a* and 6*a*, respectively, enter it.

At the corner of Laurel Hill and Skillman two small trunks enter the West Interceptor.

Design of Trunk Lines from Each Area.

As in our previous report, it has been deemed sufficient for our present purposes to investigate fully the approximate routes, grades, and maximum size of all trunk lines at the point of entrance into the interceptors. In this case, in addition, we have investigated the maximum size of the principal branches of trunk lines where they occur. It has not been deemed advisable to make a more detailed study of these trunks. Such a study would involve the detailed investigation of all existing sewers, information as to which is often meagre or totally lacking. Estimates of capacity of trunk lines are based upon water consumption and ground water flow, as previously described in our Flushing report. Provision for storm water overflows has been made at those points where these proposed lines intercept existing combined sewers, and at two points along Flushing Bay and Creek and one point at head of Newtown Creek. While the sewers have been de-

signed for sanitary and ground water flow only, until the population has been greatly increased, these provisions will suffice for storm water. Assumptions as to the relation between maximum flow and total mean flow for 24 hours have been made as described in our Flushing report. Velocities and discharges have been computed for sewers flowing full, 0.8 full, 0.5 full and 0.2 full. Maximum flows are based upon the sizes necessary at 0.8 full. In the following table the principal items involved in the design of these trunks, including maximum discharge, available slope, maximum diameter, and velocities and discharges at 0.8 and 0.2 full are given:

Design of Trunk Sewers.

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Maximum discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet	Sewer 0.8 full.		Sewer 0.2 full.	
								Velocity, sec. ft.	Discharge, sec. ft.	Velocity, sec. ft.	Discharge, sec. ft.
3a	5,000	40.00	81.84	360	6.28	125	1.83	5.75	12.30	3.00	1.08
3a, north.....	7,000	14.00	95.84	180	3.14	500	1.75	2.95	6.15	1.56	0.54
3a, south.....	4,500	15.00	96.84	180	3.14	300	1.67	3.45	6.15	1.80	0.54
2	3,000	25.00	46.84	482	8.41	120	2.00	6.33	16.49	3.30	1.45
3b	3,000	30.00	85.17	140	2.45	100	1.25	4.83	4.81	2.52	0.42
3b, 4a	6,000	33.33	55.17	406	7.09	180	2.00	5.28	13.90	2.76	1.22
3b, 4a, 2.....	2,700	4.50	21.84	888	15.50	600	2.67	3.45	15.50	1.80	1.36
14	9,000	18.00	50.44	335	5.85	500	1.75	3.88	5.85	1.50	0.51
14, 4b	4,000	10.00	32.44	508	8.88	400	2.00	3.45	8.88	1.80	0.78
5a	4,500	45.00	62.77	190	3.33	100	1.33	5.18	6.52	2.70	0.57
5b	4,500	15.00	30.34	198	3.36	300	1.67	3.45	6.59	1.80	0.58
6b	7,500	15.00	22.80	359	6.27	500	2.33	3.45	12.30	1.80	1.08
7	10,000	20.00	13.67	381	6.65	500	2.33	3.45	13.03	1.80	1.14
6a	3,000	18.00	34.25	610	10.65	200	2.33	5.53	20.90	2.88	1.81
8a	3,000	4.28	21.53	569	9.94	700	3.00	3.45	19.49	1.80	1.71
6a, 8a	4,500	3.75	16.25	1,189	20.59	1,200	3.17	2.99	20.09	1.56	1.74
6a, 8a, 8b.....	2,500	3.33	12.50	1,315	.....	750	3.00	3.45	22.29	1.20	1.80

104 Design of the Intercepting Sewer.

The design of these sewers is determined by the available slope and by the points of entrance of the various trunk lines. To facilitate reference, the two interceptors and that third line which has been called the "main branch of the East Interceptor," have been sub-divided into sections designated by letters and beginning at the upper end in each case. These sections are described as follows:

The East Interceptor.

Section A, from the upper end of the eastern edge of Area 18, along Myrtle to Cypress, to Himrod, to Covert, to Willoughby, to Onderdonk, to Troutman, to Woodward.

Sections B and C, from the corner of Woodward and Troutman across Linden Hill Cemetery upon the 60-foot contour to Metropolitan, to Nurge, to Flushing, to Grand, to Hull, to Jay and Newtown road, thence following the 40-foot contour to Railway, thence to Maurice, along Maurice to junction with Trunk No. 14 on Thompson.

Section D, a short section on Thompson, from the junction with Maurice to the junction with the present Elmhurst sewer on Broadway, intercepting the latter.

Section E, from Maurice and Broadway, along Broadway to Court, to Suydam, to Junction, to National, to Vine, to Willow, to junction with Trunk No. *5a* on Sycamore.

Section F, from Willow and Sycamore to Central and Willow at the junction with the Main Branch.

Section G, from the junction with the Main Branch along Central to Main, to Myrtle, to junction with Trunk No. *5b* on Flushing and Newtown Turnpike.

Section H, from junction with Trunk No. *5b* practically on the 20-foot contour to shorefront, thence along the shore to junction with Trunks *6b* and 7.

Section I, from the above point, still following the shore line and Shore road, to junction with Trunk *8b* at Ehret avenue and Shore road.

Section J, from Ehret avenue and Shore road along River avenue to junction with outfall sewer on Theodore.

Main Branch of the East Interceptor.

Section A, from upper end on Cooper, along Cooper to Trotting Course Lane at the junction with Trunk *3a*.

Section B, from junction on Trotting Course Lane, following valley line to 40-foot contour, thence following swamp margin to junction with Trunk No. 2 at siphon entrance.

Section C, inverted siphon under Horseshoe Creek from Newtown to Corona.

Section D, from inverted siphon along Westside avenue to South,

to Broad, to Myrtle, to Crown, to Central, to junction with East Interceptor at Central and Willoughby.

105 The West Interceptor.

Section A, from 50-foot contour line on Montgomery on southern edge of Area No. 13*c*., along Montgomery to Waters, to Washington, to Jones, to Laurel Hill Boulevard, to Borden, to Greenpoint and Borden.

Section B, from Greenpoint and Borden, along Greenpoint to Hunters Point, to Honeywell, to Thompson, to Rawson, to Foster, thence diagonally along proposed street to Skillman, skirting the Pennsylvania Railroad yards at Laurel Hill avenue at junction with two small trunks from Area No. 13*a*.

Section C, from last-named junction, still skirting the Pennsylvania Railroad yards, to Webster.

Section D, from Webster and Jackson along Webster to Prospect.

Section E, from Webster and Prospect, along Prospect to Pierce, to Crescent.

Section F, from Pierce and Crescent, along Crescent, to Grand.

Section G, from Crescent and Grand, along Crescent, to Hoyt.

Section H, from Hoyt and Crescent, along Hoyt to Howland, to Ditmars, to Barclay, to Winthrop.

Section I, from Winthrop and Barclay, along Winthrop to Blackwell, to River avenue, to junction with East Interceptor and outfall sewer on Theodore.

The total length, total fall of each section, elevation of invert at upper end of section, area contributing to each section, dimensions, slopes, velocities and discharges at 0.8 and 0.2 full, of the above-described sections of these three interceptors, are given in the following tables:

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Maximum discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
Main Branch.											
A	2,200	5.0	41.84	1,172	7.68	440	1.75	3.29	7.68	1.70	0.68
B	7,800	19.5	36.84	1,910	21.63	400	2.75	4.48	21.63	2.34	1.90
C	1,000	0.9	17.34	2,798	37.13	1,100	3.16	2.60	37.13	Siphon.	
D	5,100	3.0	16.44	3,798	37.13	1,700	4.33	2.88	37.13	1.50	3.26
East Interceptor.											
A	12,000	25.00	79.44	1,030	18.00	500	2.67	3.91	18.00	2.04	1.58
B	11,000	22.00	54.44	1,703	29.75	500	3.16	4.27	29.75	2.18	2.56
C	4,000	10.00	32.44	1,876	32.78	400	3.16	4.73	32.78	2.52	2.88
D	1,400	1.17	22.44	2,374	41.06	1,200	4.25	3.45	41.06	1.80	3.06
E	7,200	6.00	21.27	2,764	48.31	1,200	4.50	3.56	48.31	1.86	4.29
F	700	0.50	15.27	3,145	54.96	1,400	5.00	3.45	54.96	1.80	4.82
G	2,700	1.35	13.44	5,943	92.09	2,700	6.33	3.45	92.09	1.80	8.08
H	9,000	4.29	12.09	6,327	98.68	2,100	6.50	3.45	98.68	1.80	8.65
I	6,300	2.63	7.80	7,183	113.63	2,400	7.00	3.45	113.63	1.80	9.96
J	3,500	1.40	5.17	8,892	139.36	2,500	7.75	3.56	139.36	1.80	12.23
West Interceptor.											
A	4,000	13.33	50.17	149	2.6	300	1.50	3.45	5.31	1.80	0.45
B	7,200	12.00	36.84	403	7.05	600	2.00	2.76	13.82	1.44	1.21
C	3,900	5.57	24.84	1,042	18.18	700	2.84	3.45	18.18	1.80	1.60
D	2,500	2.50	19.27	1,042	18.18	1,000	3.00	2.90	18.18	1.50	1.60
E	1,400	1.17	16.77	2,519	43.95	1,200	4.33	3.45	43.95	1.80	4.16
F	3,600	3.00	15.60	2,706	47.21	1,200	4.50	3.56	47.21	1.86	4.14
G	1,800	1.50	12.60	2,706	47.21	1,200	4.50	3.56	47.21	1.86	4.14
H	5,700	3.80	11.10	3,298	57.53	1,500	5.00	3.45	57.53	1.80	5.50
I	5,300	3.53	7.30	3,691	64.39	1,500	5.33	3.56	64.39	1.80	5.65
Outfall.											
A	900	0.27	3.77	12,583	203.75	3,300	9.50	3.45	203.75	1.80	17.90

107 Provision for Storm Water.

At all points where the proposed intercepting sewers or trunks intercept existing combined systems of sewerage, present points of final discharge have been retained to serve as stormwater overflows. These points *so* far as our present information goes are as follows: On the West Interceptor overflows are provided at the corner of Hunters Point and Honeywell, and of Nott avenue and Honeywell; at Webster and Prospect; Washington and Prospect; Jamaica and Crescent; Newtown and Crescent; on Hoyt avenue; and Howland and Potter. Storm water overflows into Flushing Creek and Bay are provided on the East Interceptor for the sewage of Elmhurst Section. This matter will be discussed in some detail later in this report.

Provisions for Intercepting Existing Sewers.

On the West Interceptor it has been possible to provide for the greater part of the sewage now flowing into Newtown Creek and the East River from points at higher elevation than that of the interceptor. Such existing sewers as we have knowledge of, which can be provided for, are shown in purple ink on the accompanying map as connected with the proposed interceptor. Sewers on Graham and on Broadway in Long Island City pass under the proposed grade of the interceptor. They are, therefore, not provided for at present. It will be noted that a considerable portion of Long Island City, namely, that part of the East River front which is below the 20-foot contour, which we have called Area 12, is not provided for in this scheme. This section is so completely sewered that special future consideration will have to be given to it. Any plan which contemplates the concentration of the sewage now entering the waterfront from this area must involve a low-level interceptor following the line of Newtown Creek and the East River shore to a point in Astoria whence the sewage will have to be lifted about 25 feet to the West Interceptor. This same provision will apply to those few sewers already noted and doubtless to others of which we have no information which it is not possible to include in the present Interceptor as designed.

Disposition of the Present Elmhurst Sewage and Sewage Disposal Works.

The present plan contemplates the intercepting of the present flow from the Elmhurst Section by the East Interceptor at the corner of Broadway and Maurice avenue. It is believed that for many years to come the present plant at Elmhurst will provide satisfactorily for the disposal of all the sewage which may reach that point; and furthermore that with the advances which we may reasonably expect in the art of sewage disposal, this plant may be able to care for the entire flow from that section of the East Interceptor above Elmhurst. We therefore recommend that until condi-

tions make necessary the further extension of this final plan, the Elmhurst plant be retained to receive all the sewage from such sections of this interceptor as may be connected up from time to time; and we further recommend that studies upon improved methods of disposal, looking particularly toward economy in space and time required for treatment, be continued either at this plant or at some suitable station along the lines that are already developed at the Twenty-sixth Ward Disposal Works, or along new lines which
108 may suggest themselves to us from time to time in consequence of these installations. We urge the importance of continuing on a small scale the study of the special requirements and possibilities in this matter of sewage disposal for Greater New York. The accumulated data of such experiences will be of great value from time to time as such problems are met with.

Purification and Disposal Investigations.

Our more general studies of the ultimate capacity of New York Harbor and its tributary waters to dispose of sewage in an inoffensive manner are still in progress. We are not yet ready to report upon this matter. Before any final decision is arrived at it is desirable to carry our studies to such a point that our opinions shall be based upon a sufficient array of facts to justify them. If it be found that the waters of New York Harbor cannot continue to receive the sewage of the Metropolitan District in its crude form, but that some partial purification of a portion of that sewage at least will eventually be necessary, our plans contemplate such purification in those portions of the city where it can be carried out at a minimum expense. For this reason our studies of the two drainage districts upon which we have already reported have considered a possible necessity of some form of purification, and suitable sites for these works have been selected.

As a minimum requirement we think it necessary to provide for a proper admixture of sewage and water at the point of final discharge; such provision is of much greater importance in the case of these proposed large trunk sewers than it is with the present system of numerous small outlets. With this view in mind, we are investigating the possible methods of securing such admixture before the final discharge. If this can be accomplished it may be possible to so design our outfall works that the sewage will not rise to the surface of the stream, but will remain diffused in the lower strata. Such a result would do away entirely with one serious objection to the discharge of crude sewage into such waters as those we have to deal with, namely, the discoloration of the surface waters and other visible indications of sewage near the point of discharge.

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

109 *Special Report on the Flushing Drainage District Submitted to the Board of Estimate and Apportionment April 22, 1910.*

110 CHIEF ENGINEER'S OFFICE,
BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, April 11, 1910.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment.

SIR: At the meeting of the Board of Estimate and Apportionment held on November 12, 1909, attention was called to the need of expert advice relative to the location of points at the waterfront which might properly be used for outletting sewers, and acting on the recommendation made at that time the Board retained Colonel William M. Black, U. S. A., to investigate the matter, and with the understanding that his studies should be carried far enough to establish the extent of purification required in sections where the discharge of raw sewage would result in objectionable harbor pollution.

The desired investigation was begun early in January by Colonel Black, who had in the meantime associated with himself Professor Earle B. Phelps, and with the understanding that it would be completed during the coming summer.

After several conferences it was agreed that the field to be covered should include a general study of the districts for which no complete or permanent drainage plans have been devised and so far as required to establish the points of outlet which were practicable, both from the standpoint of sewer design and suitability for such use.

In recognition of the well-founded objections which have been raised to the use in this city of any of the methods now recognized for purification of sewage, it was also agreed that experiments should be made with a process heretofore untried but which had been suggested by Colonel Black in connection with his studies of the Passaic Valley drainage problem and which seemed to be along lines which could be advantageously followed. An experimental plant for determining the merits of this system has been installed in the East New York Purification Works, Borough of Brooklyn, and its operation has just been begun.

Several years ago the construction of a trunk system of sewers for the Ingleside section in the Borough of Queens was authorized by the Board of Estimate and Apportionment, and at a subsequent date it became necessary to abandon the plan for the outlet originally proposed, its unsuitability having been demonstrated. The sewers are now nearly completed, but no provision has yet been made for a permanent outlet; until this is obtained the system cannot be used. For this reason I suggested to Colonel Black that his attention be first given to the district in which these sewers have been built, and under date of March 30 he has submitted the accompanying report which is concurred in by Professor Phelps.

In this report it is demonstrated:

1st. That the drainage of the territory located between the backbone of the island and the East River, and extending from the westerly boundary of the Flushing Creek valley to the westerly boundary of the valley at the head of Little Neck Bay, comprising about 14,900 acres, should be considered as a whole.

111 2d. That the discharge from about 4,500 acres of low land within this area, or about 28 per cent. of the total flow, will have to be pumped, while a gravity outlet can be secured for the remainder of the district.

3d. That if further investigation should establish the feasibility of discharging all of the raw sewage directly into the East River, or if the experimental work now being conducted in the matter of an improved process of purification should give satisfactory results, practically all of the dry weather flow could be outletted about one-half mile west of Whitestone Point, and that in case of failure of the experiments and an establishment of the need of purification the discharge from the greater part of the area could be carried directly to Flushing Bay. In either case, it is believed that the lower areas of College Point, Whitestone, and Bayside can be carried to the Whitestone outlet without purification, it being held that the purification of the flow of the remaining area would permit of the discharge of the raw sewage from this territory, which forms only a small part of the whole.

4th. That if purification is required the site for the works would be located in the vicinity of Whitestone road and Bayside avenue, if the experimental process is satisfactorily developed, and otherwise in the low land north of Flushing.

5th. That the concentration point for the drainage of the low areas will be located in the vicinity of Myrtle avenue and Lawrence street.

6th. That pending the carrying out of the entire project and for a limited time the raw sewage from the Flushing section might be outletted, without purification, into the channel at the head of the bay.

7th. That all sewage should be screened before being outletted.

8th. That for the sections adjoining Flushing Creek, where combined sewers have already been built, provision should be made in the permanent plan for intercepting the dry weather flow and leading it to the outlet now recommended for the entire territory, the surplus flow during storms to be discharged as heretofore.

9th. That, where practicable, future plans for the territory in the vicinity of Flushing Creek should be based on using the separate system for so much of the area affected as is based on the outletting of the surface flow into the creek.

I would recommend that a copy of this report and of the accompanying plan be transmitted to the President of the Borough of Queens for consideration, and that his attention be directed particularly to the fact that the plan is intended to be used only as a general guide in the treatment of the problem and with the understanding that if provision is made for the removal of both storm water and the dry weather flow on the combined plan, as would seem desir-

able, it would doubtless be found practicable and advantageous to make radical changes in certain minor features.

Respectfully,

NELSON P. LEWIS,
Chief Engineer.

112

March 30, 1910.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City.

SIR: In connection with our general studies of the sewage problem of certain portions of Greater New York, we submit herewith the report upon the portion of our work which deals with that part of Queens Borough draining into Flushing Bay and adjacent waters. This section will be known in these studies as the Flushing Drainage Area.

Divisions of the Drainage Area.

For the purpose of this work the above described district has been divided into twelve sections numbered respectively one to twelve, and the section numbered "six" has been further subdivided into three divisions known respectively as *6a, 6b* and *6c*. In the estimation of populations we have allowed either twenty-five or fifty persons per acre depending upon the location of the area in question and the character of the country. Reference to the accompanying map* is invited to make clear the following description of these various drainage areas. The respective areas are marked off in heavy black lines except where such lines coincide with contour, street or stream lines, in which case they are indicated by dotted lines. Contour lines at 20-foot intervals are shown, but these are only approximate.

Maps of detailed topographical surveys were not to be obtained and funds and time for the preparation of such maps were not available. Under these conditions we were obliged to use the general map of the City of New York, prepared by the Topographical Bureau of the Board of Public Improvements, dated January 1, 1900, the topography of which is understood to have been compiled from maps issued by the United States Geological Survey.

Area No. 1—This area is situated along the shore between Whitestone Point and the point at the head of Little Neck Bay. It consists of 1,575 acres, having an estimated future population of 42,250.

Area No. 2 includes that portion of the College Point district which is above the 20-foot contour. It contains 493 acres with an estimated future population of 24,650.

Area No. 3 is a suburban district lying between No. 1 and Flushing Bay, having 1,350 acres, with an estimated future population of 35,600.

Area No. 4 includes that portion of Flushing to the north of Franklin and Sanford avenues which lies above the 20-foot contour.

* Omitted. See general map of drainage Districts of Jamaica, Corona, Flushing and Westchester, p. 148.

It consists of 524 acres, with an estimated future population of 26,200.

Area No. 5 includes that portion of the Ingleside district of Flushing, lying to the south of Franklin and Sanford avenues and extending to the crest line west of the Flushing Cemetery, which is above the 30-foot contour. It consists of 636 acres, with an estimated future population of 31,800.

Area No. 6 is the large suburban district south of Flushing extending on the south to the crest of the entire drainage area and on the west to the limits of the Flushing Creek Valley. It
113 includes a portion of Bayside and a small portion of Flushing. It consists of 5,402 acres, with an estimated future population of 135,050. For the purposes of drainage it is further subdivided into three divisions.

Area No. 7 is a small section lying to the south of Flushing between the Mill Creek Valley above the 60-foot contour and the crest of Area No. 6. It consists of 476 acres, with an estimated future population of 11,900.

Area No. 8 lies on the east side of Flushing Creek Valley, extending to the confluence with Mill Creek. It consists of 893 acres, with an estimated future population of 22,325.

Area No. 9 includes the valley of Mill Creek below the 40-foot contour line on the east side and the 60-foot contour line on the west side, down to Lawrence street. It consists of 905 acres, with an estimated future population of 22,625.

Area No. 10 includes the small district between Flushing and Mill Creeks, and Lawrence and Myrtle avenues, below the 20-foot contour, having an area of 172 acres, with an estimated future population of 8,600.

Area No. 11 includes that portion of College Point between Myrtle and Whitestone avenues and the easterly crest of Area No. 2, which is below the 20-foot contour. It has 763 acres, with an estimated future population of 19,075.

Area No. 12 is on the west side of Flushing Creek Valley and Horse Creek Valley, all below the 20-foot contour. It has 1,734 acres, with an estimated future population of 43,350.

The acreage and population of these twelve areas are tabulated below. The total area of the drainage district is 14,923 acres and the estimated future population, 423,425.

Area.	Acres.	Population.
1	1,575	42,250
2	493	24,650
3	1,350	35,600
4	524	26,200
5	636	31,800
6	5,402	135,050
7	476	11,900
8	893	22,325
9	905	22,625
10	172	8,600
11	763	19,075
12	1,734	43,350
	14,923	423,425

General Scheme of Sewerage for the District.

The project which is here proposed for the collection of the sewage of the entire Flushing drainage area is briefly as follows:

The point of final discharge is located on the East River just to the east of Powells Cove and about twenty-five hundred feet to the west of Whitestone Point. To convey the sewage to this point we
114 have provided two main systems which will be designated respectively as the "high level" and the "low level" intercepting systems. The high level system has three main branches. The first drains Area No. 1, above the 20-foot contour line; the small portion of this area which is below that line, consisting of a narrow strip along the shore, will drain directly to the waterfront. This branch meets the main interceptor at the point of discharge.

The second main branch of the high level system drains Area No. 2 above the 20-foot contour. It enters the main interceptor at the junction of Fourth avenue and Eighteenth street. The main interceptor itself may be considered to start at the point just south of the Flushing Cemetery, which is designated as Point "A." It follows Meadow road in a westerly direction, thence across country to Oak and Parsons, in Ingleside, along Oak to Colden, thence to Franklin, to Lawrence, to Washington, to Prince, to State, to Leavitt, to Whitestone, along Whitestone and Fourth avenue and on a continuation of Fourth avenue to the point of discharge. At a point in Whitestone, near Bayside avenue, suitable land is available for purification works if these be considered necessary. This point will be further discussed.

At the Point "A" previously mentioned the trunks from the Districts 6*c* and 6*b* will enter. The trunk from 6*a* joins the latter at a point shown on the map. The location of each of these trunks is sufficiently well indicated to make detailed description unnecessary. At the corner of Myrtle and Leavitt the force main from the low level interceptor enters this line. A short distance beyond at the proposed site for the sewage disposal works the trunk from Area No. 3 joins this line, and at the points already indicated the main trunks from Areas No. 1 and No. 2 enter. This high level system will therefore drain by gravity Areas Nos. 1 to 7, inclusive, a total area of 10,456 acres on which the estimated future population is 307,450.

The low level interceptor has its low point located at the pumping station near corner of Lawrence and Myrtle avenues in Flushing. To this point a small line draining Area No. 11 is brought. To this point, also, is brought the main trunk from Area No. 12, this trunk crossing Flushing Creek at the foot of Myrtle avenue by means of an inverted syphon. A third line reaches this point by closely following Flushing Creek to its end, draining Area No. 8. This latter line branches at the confluence of Flushing and Mill Creeks, one branch extending to the upper end of the valley of Mill Creek, as shown. The total area tributary to the low level interceptor is therefore made up of Areas Nos. 8 to 12, inclusive, having 4,467 acres with an estimated future population of 115,975. The future discharge of this low level system is therefore seen to be

approximately 28 per cent. of the total discharge from the Flushing drainage area.

From the pumping station to a point already indicated on the high level interceptor there will be a 30-inch cast-iron force main having a total length of approximately 3,000 feet.

Design of Main Trunk Lines from Each Area.

For the purposes of this investigation it has been deemed necessary to determine fully the route, grades and dimensions of the high level interceptor and the routes, points of entrance, and maxi-
115 mum sizes of the trunks of the various areas. It has not been considered advisable to make a more detailed study of these trunk lines. Such a study would involve a full investigation of all existing sewers, information as to which is meagre or altogether lacking. In estimating the maximum capacity of the trunk lines at their point of junction with the interceptor, or with another trunk, a water consumption of 125 gallons per capita per diem has been allowed, based upon the reports of the Chief Engineer of the Board of Estimate and Apportionment. In addition to this strictly sanitary flow an allowance of .003 cubic foot per second per acre has been made for ground water flow. This allowance is based upon the practice of the Borough Engineer of Brooklyn. No provision for storm water has been made further than the placing of storm water overflows at those points at which existing combined systems of sewerage will enter the interceptor. Upon this basis of estimate the flow is found to be .01023 and .01746 cubic feet per second per acre, for populations of twenty-five and fifty per acre respectively. It has further been assumed that of the total flow per 24 hours, half will pass in 8 hours, and upon this assumption the maximum discharge has been estimated. It is believed that this assumption is a conservative one in consideration of the size and length of the trunk sewers. Experience elsewhere has shown that in sewers of this size the ratio of maximum to average flow rarely reaches the value that we have assigned. Velocities and discharges have been computed for sewers flowing full, 0.8 full, 0.5 full and 0.2 full. Estimates of size are based upon the computation at 0.8 full. In the summary which follows it has been deemed sufficient to give this maximum velocity and discharge and the minimum velocity and discharge at 0.2 full. The dimensions, slopes, velocities and discharges of the various trunk lines are given in detail in the following tabulation:

Area No.	Maximum discharge, sec., ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec., ft.	Sewer 0.8 full. Discharge, sec., ft.	Sewer 0.2 full. Velocity, sec., ft.	Sewer 0.2 full. Discharge, sec., ft.
1	17.0	1,000	3.0	2.88	17.0	1.50	1.47
2	8.6	600	2.0	3.22	8.6	1.68	0.75
3	14.4	1,000	2.75	2.76	14.4	1.44	1.25
4	9.15	500	2.0	3.45	9.15	1.80	0.80
5	11.1	1,000	2.5	2.53	11.1	1.32	0.96
*6a	19.8	800	3.0	3.34	19.8	1.74	1.72
6b	18.8	900	3.0	3.22	18.8	1.68	16.30
6c	20.6	700	3.0	3.45	20.6	1.80	1.79
7	4.87	600	2.0	2.88	4.87	1.50	0.43
8	9.15	1,000	2.33	2.32	9.15	1.26	0.78
9	0.25	800	2.25	2.64	9.25	1.38	0.80
**8-9	18.4	1,000	3.0	3.00	18.4	1.56	1.60
10	3.0	400	1.33	2.53	3.0	1.32	0.26
**8-9-10	21.4	700	3.0	3.56	21.4	1.86	1.90
11	7.8	1,000	2.25	2.42	7.8	1.26	0.68
12	17.75	1,000	3.0	3.0	17.75	1.56	1.54
Force Main	47.0	.....	2.5	9.68 full	47.0 full	....	....

* Including No. 7.
** Below junction.

116 Design of the Intercepting Sewer.

The design of this sewer from point to point is determined by the available slopes and by the entrance of the various trunk lines. To facilitate reference the sewer will be divided into sections which are described as follows:

Section A—From point A on the map, south of Flushing Cemetery, to the Ingleside inlet, corner of Oak and Parsons.

Section B—From this point to the Flushing inlet on Broadway.

Section C—From the Flushing inlet to the force main junction on Myrtle.

Section D—From this junction to No. 3 inlet at or near the disposal works.

Section E—From No. 3 inlet to the purification works (No. 3 inlet may be at the disposal works, in which case Section E will not have to be considered).

Section F—Purification works to No. 2 inlet.

Section G—No. 2 inlet to No. 1 inlet.

Section H—Outfall sewer.

The dimensions, slopes, velocities and discharges of the high-level interceptor, subdivided into the above-described sections are given in the following table:

Section.	Maximum discharge	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
A	59.2	1,500	5.0	3.45	59.2	1.80	5.13
B	70.3	1,700	5.5	3.45	70.3	1.80	6.10
C	79.5	2,100	6.0	3.22	79.5	1.68	6.90
D	127.0	1,800	7.0	3.80	127.0	1.98	11.10
E and F	141.4	2,100	7.5	3.80	141.4	2.00	12.30
G	150.0	2,000	7.5	3.9	150.0	2.00	13.00
H	167.0	2,000	8.0	4.02	167.0	2.10	14.50

Details of Main Interceptor.

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Elevation of ground, upper end.	Contributing area, acres.
A	6,000	4.0	22.1	33.1	5,878
B	12,000	7.1	18.1	27.6	6,514
C	3,500	1.7	11.0	21.0	7,038
D	3,500	2.0	9.3	20.3	11,505
F	3,000	1.7	7.3	18.8	12,855
G	3,200	1.6	5.6	17.1	13,348
H	1,000	0.5	4.0	16.0	14,923

In order to minimize the expenses to be incurred immediately, in view of the fact that the sewers recommended are of a size suitable to serve a population greatly in excess of that at present found in the drainage area, it is recommended that the interceptors
117 and main trunk lines be constructed first of a less capacity, leaving to the future the installation of a duplicate set on the same lines.

Similarly, it is suggested that as a temporary expedient, while the sewage flow remains at its present volume a temporary outfall could be made into the channel near the head of the bay. This would be less unsanitary than the continuance of discharge through the existing outfalls into Flushing Creek, though not a condition which should be permitted to exist for any prolonged period.

Purification.

We are not prepared at the present time to report upon the degree of purification which we consider necessary in carrying out this drainage project. A site has been selected for purification works if they be found necessary. It was not feasible to determine upon a site nearer the outfall which would intercept all the sewage of the drainage area. It will be noticed that areas No. 1 and No. 2 drain into the interceptor below the purification works. Estimating upon the basis of future populations, these drainage areas will contribute about 15 per cent. of the total discharge. It is our opinion that if purification be necessary at all the remaining 85 per cent. of the discharge can be purified to such a degree that the average purification of the whole will be maintained at a point which is found desirable. In any event and as a minimum measure of purification, we are of the opinion that screening of all the sewage will be necessary. This will involve suitable screening plants on the two trunks indicated and on the main interceptor in addition to any purification which may be decided upon later.

It is recommended that an area of about three acres should be secured at once at the site recommended for the purification works. The value of property in that vicinity is increasing rapidly and should future advances in sewage purification methods make a less area necessary, the excess of land could be sold profitably.

The system, as laid out, is designed for purification by methods other than the form of sprinkling filters now in use. Should it prove necessary to adopt the method of purification by sprinkling filters, the works could be located in the existing marsh land between Flushing and College Point, and would require an area of about forty acres, and the purified effluent discharged into Flushing Bay. All of the flow entering the outfall can readily be brought to this point.

Storm Water Overflows.

The present sewerage system of Flushing is a combined system. This will be intercepted at some point on Broadway and a storm water overflow will be provided and so designed that the maximum

dry weather discharge into the interceptor allowed for Area No. 4 cannot be exceeded in times of storm. This overflow will discharge into Flushing Creek at the foot of Broadway under the bridge. In our opinion this situation is an undesirable one and future construction should as far as practicable be made upon the separate system. We do not, however, advise the complete reconstruction of this Flushing system at present.

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

118 *Special Report on the Jamaica Drainage District Submitted to the Board of Estimate and Apportionment, January 12, 1911.*

119 CHIEF ENGINEER'S OFFICE,
BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, December 12, 1910.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment:

SIR: Herewith is transmitted the progress report of Colonel William M. Black and Professor Earle B. Phelps, bearing date of November 18, 1910, concerning the investigation made by them relative to the points suitable for use as sewer outlets for the territory comprising the southern slope of the Boroughs of Brooklyn and Queens, extending from the Narrows to the Nassau County line, and also for the section adjoining the north shore in the vicinity of Little Neck Bay, the entire area being designated by them as the Jamaica Drainage District.

The area comprises about 49,000 acres which is estimated to have a total future population of about 1,700,000. Following the method used in the investigation of the Corona and Flushing districts, both of which have been reported upon to the Board, a study has been made of the lines which could be followed for the main sewers of this territory in order to reach the points selected as outlets, and the entire area has been divided into 53 drainage districts, for each of which the trunk lines are indicated, the design being worked out in such a way as to intercept sewers already built and to conform with the plans heretofore adopted in so far as practicable.

Excluding the Little Neck, Coney Island and Rockaway Beach districts, together with the area for which plans have already been prepared with provision for an outlet into the Narrows, the sanitary flow of the entire district now reported upon is to be concentrated at three points, from which it will be discharged into the waters of Jamaica Bay. These concentration points are located, respectively, at Riches Point Meadow, at the site of the Twenty-sixth Ward disposal works, and at a point on the Three-Mile Mill road, near the toe of the upland. The point first referred to is to be used as the outlet for the drainage areas heretofore laid out upon the drainage plan of the City with provision for concentration points at the exist-

ing Sheepshead Bay disposal plant and at the head of Paerdegat Basin, and also for all of the unplanned area west of the Rockaway Parkway.

The Twenty-sixth Ward disposal plant will be used for the collection of the flow from the remaining unplanned area within the limits of the Borough of Brooklyn, together with the flow from the marshland adjoining the Jamaica Bay located west of the Remsen Landing Road, and from all of the portion of the upland within the limits of the Borough of Queens south of the ridge, excepting the area lying east of the Bergen Landing Road and south of the Old Country Road.

The remaining area within the limits of the Borough of Queens, with the exception of the Rockaway Beach and Little Neck sections, is to be outletted from the third concentration point of reference.

Screening and aeration are to be ultimately provided at all of these points, the time of applying the latter and the extent of purification required depending upon the development of each of the areas.

120 Plans have already been adopted providing for the concentration of the sewage from the westerly end of Coney Island at the existing West Twelfth street station, where a chemical purification plant is in use. The investigators recommend that all of the sewage from the island be collected at this point and discharged either into the interceptor which is to extend from the pumping station located at the head of the proposed Bensonhurst Drainage Canal to the Narrows, or that it be discharged about 2,000 feet offshore and south of the westerly end of the island; it is believed that the latter treatment can be resorted to without requiring purification and without causing nuisance.

It is proposed to provide an outlet for the Rockaway section at three points from which the sewage will be discharged about 1,000 feet off-shore at a depth of about 15 feet, no treatment being required other than the removal of the grosser suspended matter, following the method now in use along the New Jersey coast. It is stated that there is "little or no probability of the sewage reaching the beach without such dilution as to make it undistinguishable."

The sewage from the Little Neck Bay section is to be concentrated at a point near the head of the bay, whence it will be forced into tidal waters, after sedimentation, screening and a certain amount of aeration.

The report includes tables giving the elements necessary for the design of the various interceptors and their tributary trunks, together with the pumping capacity required at each of the power plants which will be needed. A plan is also presented showing the boundaries of each of the drainage areas and the route, size and grade of each of the sewers proposed, together with the locations of the pumping stations, concentration points, and points of final outlet.

The study is based entirely on the drainage needs in so far as the sanitary flow is concerned, but provision has been made for storm water overflows at all points where the sanitary trunks intercept existing or authorized combined sewers.

It is understood that the experimental work which has been carried on relative to the aeration process of purification will be made the subject of an independent report, but information is now given indicating the amount of oxygen required in order to accomplish the required degree of purification at each point of outfall. It is understood that owing to a lack of necessary data the map submitted with this report is of a general character and that more precise surveys may establish a need for radical revision of the design in many particulars.

I would suggest that a copy of this report and of the accompanying map be transmitted to the President of the Borough of Brooklyn and to the President of the Borough of Queens, with the recommendation that they be given careful consideration in the preparation of the drainage plans for the areas affected.

Respectfully,

NELSON P. LEWIS,
Chief Engineer.

121 November 18, 1910.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City.

SIR: In connection with our general studies of the sewerage problems of certain portions of Greater New York, we beg to submit herewith a third report which deals with the main drainage problem of that portion of Queens Borough lying south of the ridge with a small area lying adjacent to the head of Little Neck Bay, which was not included in the Flushing District; also the southern portion of the Borough of Brooklyn, lying between the boundary of the Corona District already described and Jamaica Bay and including Coney Island, Bay Ridge and the territory directly tributary to Jamaica Bay. For purposes of convenience and identification we have designated this drainage district "The Jamaica Drainage District," and have further sub-divided it into four sections as follows:

The area south of the ridge including portions of both boroughs; the main portion of the Brooklyn area; the area adjacent to the head of Little Neck Bay, and the whole of Rockaway and Far Rockaway. These subdivisions will be known as the Queens, Brooklyn, Little Neck Bay and Rockaway Sections, respectively. Reference to the accompanying map* marked "The Jamaica Drainage District" will make more clear the discussion which follows.

Divisions of the Drainage District.

For the purposes of this study we have divided the above designated district into fifty-three drainage areas, numbered respectively 1 to 53. In the map the division lines between these areas are indi-

* Omitted. See general map of drainage Districts of Jamaica, Corona, Flushing and Westchester, p. 148.

cated by heavy dotted lines. Contour lines at 20-foot intervals are shown, but these are only approximate, by reason of the lack of detailed topographic surveys and of available time and funds for making such surveys, which has been commented upon in our first report. Our proposed sewer lines are indicated in red and other features are sufficiently described in the legend. Estimates of future populations have been made upon a basis of either twenty-five or fifty persons per acre, depending upon the location of the area in question and the character of the country. Those areas for which a population of fifty per acre has been assumed lie about Jamaica Bay and in the region of the proposed improvements. Owing to the probable character of the future population, laborers about the docks, a water consumption of 100 instead of 125 gallons per day has been allowed. This gives an "equivalent population" of forty per acre with a water consumption of 125 gallons. Our table of estimated future population is based upon this "equivalent population." The populations to be cared for in the Coney Island District and also in the Rockaway District are necessarily treated along somewhat unusual lines. In the case of Coney Island a maximum population of five hundred thousand persons, with an average water consumption of fifteen gallons per capita daily has been assumed, and the sewage has further been assumed to run off in twelve hours. This
122 estimate reduced to our usual basis of calculation is equivalent to a permanent population of seventy persons per acre, with a daily per capita water consumption of 125 gallons. Similar assumptions and calculations for the Rockaway District would give an equivalent permanent population of fifty persons, with a consumption of 125 gallons per capita per day. In other respects our assumptions as to population, water consumption, ground water run-off and ratio of maximum to average discharge are the same as were made in our Flushing report.

The areas will be sufficiently identified by reference to the map* and will be only briefly described:

Areas Nos. 1 to 10, inclusive, lie southeast of the crest line separating the Jamaica from the Flushing District, being numbered consecutively from the northeast corner. Area No. 6 is identical with the present Jamaica District, which already has a system of sewers installed. Area No. 8 is the Richmond Hill District for which sewer designs have been approved.

Areas Nos. 11, 12 and 13 comprise a small belt to the southeast of Areas Nos. 7 to 10.

Areas Nos. 14, 15, 16, 18, 19 and 20 constitute the northeastern corner of Brooklyn Borough, lying north of Rockaway Parkway.

Area No. 17 is entirely swamp land lying between Area No. 13 and Jamaica Bay.

Areas Nos. 21 to 27, inclusive, constitute a second belt lying to the southeast of the belt already described in Queens, extending from the northeastern boundary to Area No. 11, already described.

---

*Omitted. See general map of drainage districts of Jamaica, Corona, Flushing and Westchester, p. 148.

Areas Nos. 28 to 36, inclusive, constitute a third belt lying still lower and extending from the territory described to the Bay.

Area No. 20 is identical with Division "X" of the Sewer Department maps.

Areas Nos. 37 to 41, inclusive, constitute the eastern central portion of Brooklyn Borough, extending from the ridge on the west, which separates this section from the New York Bay drainage area, to Jamaica Bay on the east.

Area No. 42 comprises the whole of Coney Island.

Areas Nos. 43 to 46, inclusive, comprise the remainder of this Borough, which drains naturally to Gravesend Bay.

Area No. 39 is the District "Y."

Area No. 38 is the District "DD."

Area No. 46 is the District "W."

Area No. 45 is the District "Z."

Area No. 44 is the District "EE."

Areas Nos. 37 and 43 are the District "AA."

Area No. 42 includes the District "CC."

Areas Nos. 47 to 50, inclusive, are situated adjacent to and drain into Little Neck Bay.

Areas Nos. 51 to 53, inclusive, include the entire Rockaway and Far Rockaway Districts.

The acreage and future estimated populations of these various drainage areas are tabulated below.

The total area included in the district is 48,916 acres, and the total estimated future population is 1,661,495.

Area No.	Acres.	Assumed future "equivalent population." Per acre.	Total.
1	1,634	25	40,850
2	1,010	25	25,250
3	637	25	15,925
4	794	25	19,850
5	319	25	7,975
6	1,259	25	31,475
7	734	40	29,360
8	576	40	23,040
9	628	40	25,120
10	576	40	23,040
11	844	40	33,760
12	334	40	13,360
13	384	40	15,360
14	1,003	40	40,120
15	432	40	17,280
16	1,231	40	49,240
17	1,288	40	51,520
18	949	40	37,960
19	945	40	37,800
20	1,216	40	48,640
21	360	25	9,000
22	663	25	16,575
23	837	25	20,925
24	540	25	13,500
25	299	25	7,475
26	661	25	16,525
27	750	25	18,750
28	500	25	12,500
29	357	25	8,925
30	1,266	25	31,650
31	1,671	25	41,775
32	905	25	22,625
33	1,408	25	35,200
34	1,067	25	26,675
35	696	40	27,840
36	707	40	28,280
37	1,400	25	36,500
38	1,650	40	66,000
39	2,408	40	96,320
40	652	40	26,080
41	950	40	38,000
42	1,152	70	80,640
43	1,312	25	32,800
44	629	25	15,725
45	906	25	24,900
46	2,104	40	84,160
47	1,079	25	26,975
48	724	25	18,100
49	479	25	11,975
50	555	25	13,875
51	1,309	50	65,450
52	811	50	40,550
53	1,106	50	58,300
Total	48,916		1,961,405

Queens Section.

This section will have two main concentration points, one at the present Twenty-sixth Ward Pumping Station on Second Creek, the other at Third-Mile Mill on Cornell Creek. These concentration points are indicated on the map as "A" and "B," respectively. The sewage will be brought to point "A" by three gravity systems, one draining Areas 17 and 18, the second draining Areas 19 and 20, and the third draining the high-level district included in Areas 1 to 16, inclusive. This interceptor will be known as Interceptor No. 1 and a branch interceptor serving Areas 11, 12 and 13 will be known as Interceptor No. 2.

From point "A" the sewage will be forced through three four-foot cast-iron force mains to a point in Big Fishkill Channel. When the thirty-foot channel is excavated in front of the bulkhead line, the outfall sewers must be discharged into it, as the circulation in Fishkill and Broad Channels will then be markedly lessened, and the points of discharge shown will be in water of less depth. In this as in all cases, the most efficient means possible should be taken to insure diffusion of the sewage effluent in the sea water at the outlet so as to avoid a surface nuisance.

The remaining portions of Queens will drain to concentration point "B" by two main interceptors: Areas 21 to 27, inclusive, are served by high-level interceptors known as Interceptor No. 3; Areas 28 to 34, inclusive, by a low-*level* interceptor known as Interceptor No. 4; and areas No. 35 and No. 36 by a trunk line with two branch lines leading directly to point B.

From point B the sewage will be forced through two four-foot cast-iron force mains to a point in Broad Channel shown on the map.

A discussion of the ability of the waters of Jamaica Bay to dispose successfully of the sewage from these two outlets, without the production of any nuisance, will be deferred to a later section of this report, under the head "Pollution of the Waters and Purification Necessary."

Brooklyn Section.

This section, with the exception of areas adjacent to the Queens boundary line, and which have been included in the Queens section, is already provided with sewer systems or with approved designs. Our proposed plans contemplate certain additions to the existing systems as follows: According to plans already approved, the flow from areas Nos. 43, 44 and 45 will be concentrated at point "E," from which it will be forced by pumping to the final outlet in the Narrows, just above Fort Hamilton. The flow from Coney Island concentrates at "CC," on West Twelfth street and Neptune avenue.

To dispose of the sewage concentrated at this point, we present two alternative projects: First, to lift the flow to a gravity line, leading through a siphon under Gravesend Canal, along Eleventh street and Avenue W to the concentration point "E." The objection to this

plan lies in the pumping of the sewage cityward and discharging it into the Upper Bay, where conditions are not favorable for its reception. The second project contemplates pumping the flow from "CC" seaward, discharging about two thousand feet from shore. To permit this there must be found a point of discharge free from
125 the danger of a return upon the beach. In this project a point has been selected well toward the western end of the Island, and the discharge will be in the path of the current around Nortons Point, so that no return of the sewage to the beach is anticipated.

The easterly section of the Brooklyn District, comprising drainage areas 37 to 41, inclusive, is, with the exception of areas 40 and 41, already provided with approved drainage plans. Areas 38 and 39, shown on the Sewer Department plans as "DD" and "Y," respectively, concentrate at point "N" on Flatlands avenue and Paerdegat Basin. Area 37, being the eastern part of the Sewer Department district "AA" concentrates at a point "P" at Knapp street and Avenue Y. The proposed plan contemplates the concentration of the flow from areas 40 and 41 at a point "M" on Ralph avenue and Avenue T.

A gravity interceptor will collect the sewage from these three points (N, P and M), and conduct it to the proposed disposal works in Riches Point Meadow for treatment. This line will be known as Interceptor No. 5. The sewage concentrated at "M" will be lifted directly to the interceptor at Ralph avenue and Avenue T; the flow of areas 38 and 39 will be lifted to a gravity line leading down Ralph avenue to the interceptor, and the flow concentrated at "P" will be lifted to a gravity line joining the interceptor at Avenue T and Flatbush avenue.

The extent and character of the treatment at the purification works will be discussed in a later section of this report. From these works the discharge will be by means of a 54-inch cast-iron pipe to a point in Rockaway Inlet, as indicated.

Little Neck Bay Section.

This section includes a small area with steep slopes and the design is simple. It is not considered advisable to attempt to carry the sewage from this section into the swifter waters of the Sound. Owing to the shallow character of the Bay and the absence of currents, purification works have been indicated near the point of discharge. The subject of purification will be dealt with in a later section of this report.

Rockaway Section.

The Rockaway section comprises low and flat land. The sewage will be collected at three concentration points with a low level trunk running the entire length of the section. From these points it will be discharged through three outfall sewers extending approximately one thousand feet from shore into water 15 feet deep, where there is little or no probability of the sewage reaching the beach without

such dilution as to make it undistinguishable. The question of the degree of purification necessary in these cases will be discussed in a later section of this report.

Trunk sewers designated in general by the number of the area served will enter these interceptors and concentration points as follows:

Interceptor No. 1.

Trunk No. 1, from the 120-foot contour line on Little Neck road, following Little Neck road and Jericho turnpike to junction with Rocky Hill road.

Trunk No. 2, from near Marvin road, along Clinton avenue to Rocky Hill road, thence to junction point above.

126 Trunk No. 3, from Chestnut, along North Wertland to interceptor on Jericho turnpike.

Trunk No. 4*a* on Hillside avenue, from Vogel to Cornwall to Prospect to Palatina to interceptor on Hempstead and Jamaica Plank road.

Trunk No. 4*b*, from Kilbourn avenue and Old Country road along the latter to interceptor on Plank road.

Trunk No. 5, from Orchard and Hillside along latter to Columbus to interceptor on Fulton.

Trunk No. 6. This trunk is already constructed as a part of the Jamaica system. It runs along Lincoln avenue to the junction with the Hawtree Creek road. An 8-inch branch runs along Van Wyck avenue and Hawtree Creek road to the same junction. At its junction with the road to Bergens Landing its diameter is 2 feet 0 inches; its grade 1 in 750; and its elevation + 15.85. A short branch from this point to the Interceptor on South street is designed. This design, in accordance with the general plan of these studies, is based upon estimated future population, and it is, therefore, larger than the existing trunk, which it serves. The latter will undoubtedly suffice for a considerable period in the future.

Trunk No. 7, from Metropolitan avenue along Gould street to Washington, to Chestnut, to Muh and Atfield avenue, to junction with interceptor on Van Sicklen avenue.

Trunk No. 8. This trunk is already designed as a part of the system of the Richmond Hill section, as shown on Map B-4755, on file in the office of the Chief Engineer, Board of Estimate and Apportionment. It is planned to intercept this trunk at its junction with the interceptor on Metropolis avenue.

Trunk No. 9, from Jamaica avenue to Napier, along the latter to Hatch, to interceptor on Liberty.

Trunk No. 10 (*a*), on Atlantic avenue from Thrall to interceptor on Rockaway Plank road.

Trunk No. 10 (*b*), from Jamaica avenue and Snedeker, along latter to interceptor on Atlantic avenue.

Trunk No. 14, from Hendrix and Belmont, along latter to Fountain to interceptor on Sutter.

Trunk No. 15, from Blake and Cleveland, along latter to New Lots, to Schenck, to interceptor on Wortman.

Trunk No. 16, from Belmont and Stone, along latter to Lott, to New Lots, to Pennsylvania, to Wortman, to interceptor on Hendrix.

Interceptor No. 2.

Trunk No. 11, on Hawtree Creek road, from the 40-foot contour line to Old South road, thence to head of Interceptor No. 2, at Centreville avenue.

Trunk No. 12, from Rockaway Plank road along Centreville avenue to the interceptor on Old South road.

Trunk No. 13 (*a*), from Ocean avenue and Park street, along Park to Woodhaven to Sutter to the cemetery to interceptor on Old South road.

Trunk No. 13 (*b*), from Atlantic avenue and Spruce along Spruce to Liberty to interceptor on Liberty.

127 Concentration Point A.

Trunk No. 17. This trunk is not definitely located, but will run through the central portion of Area No. 17 to Mill road.

Trunk No. 18, along Railroad avenue and Mill road, intercepting No. 17 on the latter.

Trunks Nos. 17-18, from above point of junction around head of Spring Creek Basin to concentration point A.

Trunk No. 19 will drain the southerly portion of Area No. 19 and will run along East One Hundred and Eighth street to Flatlands avenue, siphon under Fresh Creek Basin to discharge into Trunk No. 20, as shown.

Trunk No. 20. This is an intercepting trunk line draining Area No. 20, which is known as "X" on Sewer Department Maps of Brooklyn Borough. Flowing 0.8 full this trunk will amply provide for the future sanitary flow from Areas No. 19 and No. 20.

Interceptor No. 3.

Trunk No. 21 (*a*), from Long Island Railroad along Creed avenue to the upper end of the interceptor at Hollis.

Trunk No. 21 (*b*), from Claremont and Old Country road along the latter to the upper end of interceptor on Hollis.

Trunk No. 22 (*a*), on Old Country road to interceptor on Springfield.

Trunk No. 22 (*b*). This trunk will flow between the 45-foot and 55-foot contour lines through the northeastern section of Area No. 22. It is not definitely located. It will enter the interceptor at Central avenue and Springfield.

Trunk No. 23 (*a*), from a point on Bank avenue, near Springfield road, along Bank to Farmers to interceptor on Central.

Trunk No. 23 (*b*). This trunk is not definitely located, but will run from the northerly boundary of Area No. 23 in a southerly direction to Farmers avenue to the interceptor on Central.

Trunk No. 24, from Long Island Railroad and William street along latter across South street, thence through an unmapped territory to Canton avenue to interceptor on Central.

Trunk No. 25, from Farmers avenue and Merrick along latter to interceptor on Central.

Trunk No. 26 (*a*), from Cumberland and High View along prolongation of latter to interceptor on Anita.

Trunk No. 26 (*b*), from Cumberland and Brown along latter to Norris to interceptor on Meyer.

Trunk No. 27, along Rockaway Plank road, from point near Bergens Landing road to Birch to Central to interceptor on Three Mile Mill.

Interceptor No. 4.

Trunk No. 28, from Long Island Railroad and Rosedale avenue along latter to prolongation of Cherry avenue, thence to upper end of Interceptor No. 4 at Cherry and Old Fosters Meadow road.

Trunk No. 29. This trunk is not definitely located, but will run along the southwestern boundary of the area to the upper end of Interceptor No. 4.

128 Trunk No. 30, along Old Fosters Meadow road from City limits to upper end of Interceptor No. 4.

Trunk No. 31, along Rockaway turnpike, from Hook Creek to Country road, thence to interceptor on Cherry.

Trunk No. 32, along Springfield road, from Clifton avenue to interceptor on Cherry.

Trunk No. 33, along New York avenue, from Long Island Railroad to Nicholas to Rockaway turnpike to Garfield to interceptor on Eighth street, in Idlewild Park.

Trunk No. 34, along Marsh road, from near the waterfront to interceptor on Eighth street, Idlewild Park.

Concentration Point B.

Trunk No. 35. This trunk is not definitely located, but will run in a northeasterly direction through the central portion of Areas Nos. 35 and 36 around head of Bergen Basin to junction with Trunk No. 36.

Trunk No. 36 (*a*) and No. 36 (*b*). These trunks are not definitely located, but will drain the northerly and southerly halves, respectively, of Area No. 36, uniting with Trunk No. 35 at a common junction.

Trunks Nos. 35-36, from the above junction point to Concentration Point B.

Eastern Brooklyn District.

Trunk No. 37, from concentration point P along Avenue Y, Coyle street, Avenue U, Bragg street and Avenue T to interceptor at Flatbush.

Trunks Nos. 38-39, from existing concentration point N along Ralph avenue to interceptor on Avenue T.

Coney Island Section.

Trunk No. 42, from existing concentration point CC under Gravesend Bay Canal along West Eleventh street and Avenue W to existing concentration point E. To be used in case sewage is not discharged into sea directly.

Little Neck Bay Section.

Trunk No. 47, from City line following the valley in the centre of Area No. 47 in a southerly direction, thence still following valley in a northwesterly direction to Broadway, to Pine street, to Orient, to Willow, to Main at Junction with Trunk No. 48.

Trunk No. 48, from point at head of Alley Pond along Alley road, and thence following closely 40-foot contour line in a northwesterly direction to junction with Trunk No. 47 at Willow and Main.

Trunks Nos. 47-48, from the above junction point along Main to Cedar to purification works near head of Little Neck Bay.

Trunk No. 49, from West Alley road, near head of Alley Pond, following 40-foot contour line to junction with Trunk No. 50 on edge of swamp.

Trunk No. 50, from a point to the west of Oakland Lake following 30-foot contour line around Lake to junction with Trunk No. 49.

Trunks Nos. 49-50, from above junction point through meadow under creek to purification works. The kind and degree of purification to be given the sewage at this point will be discussed in a later section of this report.

129 ## Rockaway Section.

The three areas comprising the Rockaway section will be served by three separate systems with independent concentration points and outlets.

Trunks Nos. 51 (*a*) and 51 (*b*). These two trunks run parallel to the shore from the two ends of Area No. 51 to the concentration point X, located as shown.

Trunks Nos. 52 (*a*) and 52 (*b*). These two trunks drain Area No. 52 in a similar manner and concentrate at point Y, as shown.

Trunk No. 53. This trunk runs along the southern boundary of Area No. 53 from near the City limit to the concentration point Z, in the southern corner of the area.

Purification works are provided at each of these concentration points. The kind and degree of purification necessary will be discussed in a later section of this report.

Design of Trunk Lines from Each Area.

As in our previous report, it has been deemed sufficient for our present purposes to investigate fully the approximate routes, grades and maximum size of all trunk lines at the point of entrance into the

interceptor. It has not been deemed advisable to make a more detailed study of these trunks. Such a study would involve the detailed investigation of all existing sewers, information as to which is often meagre or totally lacking. Estimates of capacity of trunk lines are based upon water consumption and ground water flow, as previously described in our Flushing report. Provision for storm-water overflows has been made at those points where these proposed lines intercept existing combined sewers, namely, at the intersection of Trunk No. 6, at Lincoln avenue and Hawtree Creek road; and of Trunk No. 8, on Metropolis avenue; and of Trunk No. 20, previous to its junction with No. 19. The first two overflows will continue in existing or approved sewers to the present Jamaica Disposal Plant; the third by a new overflow to Fresh Creek. While the sewers have been designed for sanitary and ground water flow only, until the population has been greatly increased, these provisions will suffice for storm water. Assumptions as to the relation between maximum flow and total mean flow for 24 hours have been made as described in our Flushing report. Velocities and discharges have been computed for sewers flowing full, 0.8 full, 0.5 full and 0.2 full. Sizes are based upon the normal flow, sewer 0.5 full. In the following table the principal items involved in the design of these trunks, including maximum discharge, available slope, maximum diameter and velocities and discharges at 0.8 and 0.2 full are given:

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Maximum discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
1	10,200	34.00	112.55	1,634	16.72	300	3.00	5.52	32.80	2.88	2.84
2	5,300	29.45	108.50	1,010	10.33	180	2.33	5.75	20.23	3.00	1.76
3	4,200	21.00	88.92	637	6.52	200	2.00	4.83	12.78	2.52	1.11
4 (a)	6,350	52.92	91.27	529	5.42	120	1.67	5.64	10.62	2.94	0.92
4 (b)	6,350	21.17	51.95	265	2.71	300	1.50	3.34	5.31	1.74	0.46
5	5,700	45.60	73.11	319	3.26	125	1.50	4.95	6.39	2.58	0.55
6	875	1.65	15.85	1,259	12.88	500	3.00	4.26	.....	2.22	....
7	4,850	38.80	54.00	734	10.69	125	2.17	6.67	19.99	3.48	1.73
8	*.....	.....	.....	576	8.39	...	.....	.....	.....	....	....
9	5,500	36.67	40.85	628	9.15	150	2.17	5.87	17.91	3.06	1.55
10 (a)	2,300	27.05	26.83	288	4.19	85	1.50	5.87	8.21	3.07	0.71
10 (b)	3,150	52.50	52.28	288	4.19	60	1.33	6.78	8.21	3.54	0.71
11	10,570	26.43	28.66	844	12.29	400	2.83	4.49	24.02	2.34	2.09
12	3,500	28.00	31.73	334	4.86	125	1.58	5.40	9.52	2.82	0.83
13 (a)	1,700	24.28	23.65	256	3.72	70	1.33	6.22	7.28	3.24	0.63
13 (b)	1,700	13.00	10.70	128	1.86	125	1.17	4.14	3.65	2.16	0.32
14	4,450	22.50	20.14	1,003	14.59	200	2.67	5.98	28.57	3.12	2.48
15	5,050	16.82	12.86	432	6.29	300	2.00	4.14	12.53	2.16	1.19
16	11,400	32.58	28.81	1,231	17.92	350	3.17	5.18	35.12	2.70	3.72
17	9,100	8.27	3.27	1,288	18.75	1,100	4.00	3.45	36.75	1.80	3.18
18	4,000	8.00	3.00	475	6.90	500	2.50	3.45	13.52	1.80	1.17
17-18	5,000	5.00	—5.00	2,237	32.55	1,000	3.67	8.45	32.55	1.80	2.82
19	7,350	8.17	—0.61	945	13.78	900	3.50	3.45	27.00	1.80	2.34
19-20	†.....	.....	.....	2,161	30.03	...	3.50	.....	.....	....	....

* Already designed. † Constructed.

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Normal discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full.		Sewer 0.2 full.	
								Velocity, sec. ft.	Discharge, sec. ft.	Velocity, sec. ft.	Discharge, sec. ft.
21 (a)	2,300	11.50	68.89	180	1.84	200	1.25	3.45	3.61	1.80	0.31
21 (b)	3,400	5.67	63.06	180	1.84	600	1.50	2.30	3.61	1.20	0.31
22 (a)	3,800	19.00	57.39	331	3.39	200	1.67	4.26	6.64	2.22	0.58
22 (b)	4,750	13.58	46.46	332	3.39	350	1.75	3.45	6.64	1.80	0.58
23 (a)	6,350	10.59	31.28	418	4.28	600	2.00	3.10	8.38	1.62	0.73
23 (b)	6,350	35.28	56.31	419	4.28	180	1.67	4.60	8.38	2.40	0.73
24	6,750	15.00	33.82	540	5.52	450	2.17	3.45	10.82	1.80	0.94
25	6,150	6.83	22.11	299	3.06	900	2.00	2.30	5.99	1.20	0.52
26 (a)	2,650	6.63	19.56	220	2.29	400	1.50	2.88	4.49	1.50	0.39
26 (b)	3,150	7.88	18.55	441	4.47	400	2.00	3.45	8.76	1.80	0.76
27	6,300	10.50	14.00	750	7.67	600	2.50	3.45	15.03	1.80	1.30
28	9,950	9.95	12.27	500	5.11	1,000	2.50	2.53	10.01	1.32	0.87
29	4,000	4.00	6.32	357	3.65	1,000	2.17	2.30	7.16	1.20	0.62
30	10,550	21.10	23.42	1,286	12.93	500	3.00	4.26	25.38	2.22	2.20
31	9,700	9.70	6.39	1,671	17.10	1,000	3.75	3.45	33.75	1.80	2.91
32	9,300	14.31	13.00	905	9.26	650	2.75	3.45	18.14	1.80	1.57
33	12,000	13.33	6.50	1,408	14.40	900	3.50	3.45	28.22	1.80	2.45
34	6,600	9.44	2.44	1,067	10.90	700	3.00	3.45	21.38	1.80	1.85
35	7,000	10.00	3.93	696	10.13	700	3.00	3.45	20.02	1.80	1.74
36	3,170	7.46	1.39	354	5.15	425	2.17	3.45	10.09	1.80	0.87
35-36	2,750	3.93	—6.07	1,050	20.42	700	3.00	3.45	20.42	1.80	1.77

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Maximum discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full.		Sewer 0.2 full.	
								Velocity, sec. ft.	Discharge, sec. ft.	Velocity, sec. ft.	Discharge, sec. ft.
37	8,000	8.80	1.64	1,460	14.94	900	3.5	3.45	29.27	1.80	2.54
38-39	6,260	4.13	1.45	4,058	50.07	1,500	5.17	3.45	50.97	1.80	5.13
42	5,260	4.16	—6.47	1,152	26.62	1,250	4.83	3.45	54.35	1.80	4.62
47	19,850	172.50	177.09	1,079	11.06	115	1.67	5.75	11.06	3.00	0.96
48	8,050	44.70	49.29	724	7.41	180	1.67	4.37	7.41	2.28	0.64
47-48	2,750	4.59	4.59	1,803	18.47	600	2.75	3.45	18.47	1.80	1.61
49	4,450	29.65	36.65	479	4.81	150	1.25	4.14	4.81	2.16	0.42
50	5,050	29.70	36.70	555	5.68	170	1.50	4.14	5.68	2.16	0.49
49-50	3,150	7.00	7.00	1,034	10.49	450	2.17	3.45	10.49	1.80	0.91
51 (a)	9,000	10.00	0.00	827	14.44	900	3.50	3.45	28.32	1.80	2.46
51 (b)	7,400	12.33	2.33	482	8.41	600	2.67	3.45	16.50	1.80	1.43
52 (a)	9,500	10.56	0.56	390	6.81	900	2.67	2.88	13.36	1.50	1.17
52 (b)	11,600	11.60	1.60	421	7.35	1,000	2.75	2.88	14.40	1.50	1.25
53	6,300	5.25	0.25	1,166	20.37	1,200	4.17	3.45	39.90	1.80	3.46

133 Design of the Intercepting Sewers.

The design of these sewers is determined by the avilable slope and by the points of entrance of the various trunk lines. Sizes are based upon normal flow, sewers 0.8 full. To facilitate reference, the five interceptors have been subdivided into sections designated by letters and beginning at the upper end in each case. These sections are described as follows:

Interceptor No. 1.

Section A, from Rocky Hill road and North Jericho turnpike along latter to North Wertland avenue.

Section B, from last-named point along Jericho turnpike and Hempstead and Jamaica Plank road to Palatina avenue.

Section C, from last-named point to Old Country road.

Section D, from last-named point along Fulton to Columbus avenue.

Section E, from last-named point along Fulton to Skidmore to Willow to Candace to Larch and South to Wells.

Section F, from last-named point along First street to Van Wyck to Wyoming to Van Sicklen.

Section G, from last-named point along Van Sicklen to Metropolis to Lefferts.

Section H, from last-named point along Metropolis to Hamilton to Liberty to Hatch.

Section I, from last-named point to Rockaway Plank road to Atlantic avenue.

Section J, from last-named point along Atlantic avenue to Elderts lane to Liberty.

Section K, from last-named point along Elderts lane to Glenmore to Railroad avenue to Sutter to Fountain.

Section L, from last-named point along Fountain to Vienna to Atkins to Stanley to Sheppard to Wortman to Schenck.

Section M, from last-named point along Wortman to Hendrix.

Section N, from last-named point to concentration point A.

Section O, outfall force mains from concentration point A to Big Fishkill Channel.

Interceptor No. 2.

Section A, from Centerville avenue and Old South road at junction of Trunks 11 and 12, thence along Old South road to Acacia Cemetery.

Section B, from last-named point around cemetery to Liberty.

Section C, from last-named point along Liberty to junction with Interceptor No. 1 on Elderts lane.

Interceptor No. 3.

Section A, from junction of Trunks 21 (*a*) and 21 (*b*) on Hollis and Springfield along latter to Old Country road.

Section B, from last-named point along Springfield to Central.

Section C, from last-named point along Central to Farmers avenue.

Section D, from last-named point along Central to Canton.

Section E, from last-named point along Central to Merrick road.

134 Section F, from last-named point along Merrick road to Anita, thence to Vine.

Section G, from last-named point along prolongation of Meyer avenue and Claude place to Norris.

Section H, from last-named point along Norris to Campbell to Rockaway turnpike to Rockaway Plank road to Three Mile Mill road to Central avenue.

Section I, from last-named point along Three Mile Mill to concentration point B.

Section J, from concentration point B by pressure force mains to point on Broad Channel.

Interceptor No. 4.

Section A, from junction of Trunks 28, 29 and 30 at Old Fosters Meadow road along Cherry avenue to Country road.

Section B, from last-named point along Cherry avenue and Eighth street to Garfield avenue.

Section C, from last-named point along Eighth street to concentration point B.

Interceptor No. 5.

Section A, from junction with Trunks 38-39 on Ralph avenue along Avenue T to junction with Trunk 37 on Flatbush avenue.

Section B, from Avenue T along Flatbush avenue to a southeasterly direction to purification works on Riches Point Meadow.

Section C, cast-iron force main from purification works to a point in Rockaway Inlet.

Design of the Outfall Sewers.

In addition to the three outfall sections of main interceptors, formerly described, there are five outfall sections contemplated in the proposed plans. Three of these are located on the shore front of the Rockaway District and one in Little Neck Bay, one in Coney Island (alternative project). These will be known as Rockaway Outfall Sewers No. 1, No. 2 and No. 3; Little Neck Bay Outfall Sewer; and Coney Island Outfall Sewer; serving Areas Nos. 51, 52 and 53, the Little Neck Bay District and Area No. 42, respectively.

The total length, total fall of each section, elevation of invert at upper end of section, area contributing to each section, dimensions, slopes, velocities and discharges at 0.8 and 0.2 full, of the above-described sections of these five interceptors, are given in the following tables:

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Normal discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
Interceptor No. 1.											
A	4,050	11.63	78.35	2,644	27.05	400	3.00	4.69	27.05	2.49	2.35
B	8,870	29.57	66.92	3,281	33.57	300	3.00	5.32	33.57	2.88	2.91
C	1,080	8.45	37.35	3,810	38.10	200	3.00	6.67	38.10	3.48	3.38
D	2,110	3.52	28.90	4,075	41.70	600	3.75	4.49	41.70	2.34	3.62
E	11,180	11.18	25.38	4,394	44.16	1,000	4.25	3.68	44.16	1.92	3.90
F	2,110	1.05	14.20	5,653	57.84	1,400	5.00	3.56	57.84	1.86	5.02
G	4,800	4.86	12.70	6,387	68.53	1,000	5.00	4.26	68.53	2.22	5.85
H	5,280	6.41	7.84	6,993	76.92	825	5.00	4.69	76.92	2.40	6.67
I	5,280	4.40	1.43	7,591	86.07	1,200	5.50	4.34	86.07	2.16	7.47
J	3,300	3.67	—2.97	8,167	94.45	900	5.50	4.71	94.45	2.46	8.18
K	4,800	1.22	—6.64	9,729	117.18	4,000	7.75	2.88	117.18	1.50	10.16
L	6,550	1.60	—7.86	10,732	131.77	4,100	8.25	2.88	131.77	1.50	11.43
M	200	0.06	—9.46	11,164	138.06	4,200	8.50	2.90	138.06	1.56	11.97
N	2,110	0.48	—9.52	12,395	155.98	4,400	9.00	2.90	155.98	1.56	13.53
O	14,980	13.50*	—10.00**	16,793	218.56	...	3@4.00	Force Mains.			
Interceptor No. 2.											
A	4,440	4.44	2.23	1,178	17.15	1,000	3.00	3.09	17.15	1.62	1.49
B	2,330	2.33	—2.21	1,454	20.87	1,000	3.17	3.22	20.87	1.68	1.81
C	2,110	2.11	—4.53	1,562	22.73	1,000	3.25	3.22	22.73	1.68	1.97

* Lift (Max. Value).
** El. of Surface in Pump Well.

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Contributing area, acres.	Normal discharge, sec. ft.	Slope 1 foot in	Maximum diameter, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
Interceptor No. 3.											
A	3,800	19.00	37.39	200	3.68	200	1.25	3.45	3.68	1.80	0.32
B	1,900	5.84	38.39	692	7.07	325	1.75	3.45	7.07	1.80	0.61
C	5,710	12.69	32.55	1,023	10.46	450	2.17	3.45	10.46	1.80	0.91
D	1,480	2.12	19.86	1,860	19.02	700	2.17	3.45	19.02	1.80	1.65
E	3,170	3.96	17.74	2,400	24.54	800	3.25	3.45	24.54	1.80	2.13
F	2,325	2.69	13.78	2,640	27.00	900	3.50	3.45	27.00	1.80	2.40
G	2,110	2.34	11.18	2,940	29.80	900	3.50	3.45	29.80	1.80	2.60
H	6,340	6.34	8.84	3,360	34.36	1,000	3.83	3.45	34.36	1.80	2.98
I	4,300	12.50	2.50	4,110	42.03	900	3.50	3.91	42.03	2.82	3.65
J	12,600	13.50*	—10.00**	12,087	135.82	...	2 @ 4.00	Force Mains.			
Interceptor No. 4.											
A	4,500	5.03	2.32	2,123	21.71	800	3.00	3.45	21.71	1.80	1.88
B	7,400	5.03	—3.31	4,020	48.07	1,300	4.67	3.45	48.07	1.08	4.26
C	1,700	1.00	—9.00	7,174	73.37	1,700	5.67	3.45	73.37	1.80	6.36
Interceptor No. 5.											
A	3,000	1.67	—5.58	5,030	82.41	1,800	6.00	3.45	82.41	1.80	7.14
B	10,000	4.75	—7.25	7,120	97.35	2,100	6.50	3.45	97.35	1.80	8.44
C	5,280	15.40*	—12.00**	7,120	97.35	...	4.50	Force Mains.			
Additional Force Main Out Falls.											
1	1,200	74.00*	—10.00**	1,300	22.85	...	2.25	.....	.....	.....	.....
2	1,300	13.00*	—10.00**	811	14.16	...	1.67	.....	.....	.....	.....
3	2,000	8.00*	—5.00**	1,106	20.37	...	2.00	.....	.....	.....	.....
4	2,000	5.50*	0.00**	2,837	28.16	...	2.50	.....	.....	.....	.....
5	11,000	62.58	—0.78**	1,152	26.62	...	2.50	.....	.....	.....	.....

* Lift (Max. Value).
** El. of surface in Pump-well.

137 Pumping Stations.

These plans contemplate the establishment of eleven pumping stations, the ultimate maximum capacities and approximate locations of which are as follows: The capacities given are net horse power, without reference to efficiency, and refer to total lift between pump-well level and ordinary maximum high tide, in the case of out-fall works, or between the two fixed levels in case of subsidiary pumping stations. This power is also referred to the same maximum run-off for which our sewers are designed, namely, at the rate of half the total daily run-off of sewage in eight hours, plus the normal hourly rate of ground water flow.

In that section which we have described as the Queens Section, the drainage is entirely by gravity to the concentration point "A." At this point a pumping station having a capacity of 951 net horse power will be required.

At concentration point "B" the drainage is likewise collected by gravity systems. At this point a pumping station having a net capacity of 535 horse power will be required.

In the easterly Brooklyn Section five pumping stations have been designed. One located at concentration point "N" will lift the entire drainage from Areas 38 and 39 to gravity trunk designated 38-39. There will be required a capacity of 102 net horse power. A second station is located at concentration point "P," the capacity required being 29 net horse power. At concentration point "M" a pumping station will lift the discharge from Areas 40 and 41 into the gravity line running to the purification works. The capacity of this station will be 24 net horse power. At the purification works a fifth pumping station with a capacity of 258 net horse power will be provided.

In the Western Brooklyn Section the discharge in Trunk 42 will be lifted by a pumping station located at concentration point "CC" into a gravity line running to concentration point "E". A capacity of 15 net horse power will be required. A pumping station at "E" is already designed and it is not discussed in this report. In the alternative Coney Island project, a pumping station for the outfall at "CC" will be required with a capacity of 190 net horse power.

In the Little Neck Bay Section a pumping station located at the purification works will lift the entire discharge of this area and force it through the outfall sewer. A capacity of 48 net horse power will be required.

In the Rockaway Section three small pumping stations, one at each outlet, are provided. That serving Area No. 51 will have a capacity of 49 net horse power, that serving Area No. 52, 34 net horse power, and that serving Area No. 53, 47 net horse power.

Pollution of the Waters and Purification Necessary.

In our previous reports matters relating to water pollution and the purification of sewage were left in abeyance until the completion of our experimental investigation into the condition of the waters of

New York Harbor, and their ultimate capacity to receive sew-
138 age without giving rise to undesirable conditions. This present report deals with the drainage area which is for the most part adjacent to waters which do not constitute a factor in the New York Bay problem. In the location of the seven outfall points which we have selected for this drainage area, therefore, we have given careful attention to the probable effect of such a plan of drainage upon the adjacent waters. The larger part of this entire drainage area, namely,, the Queens and Brooklyn Districts, drains into the waters of Jamaica Bay. Careful investigation of the total amount of water entering this bay from the ocean, during each tidal period, has been made, and by a study of the relative cross sectional areas of the more important channels within the bay and of the tidal prisms tributary to these respective channels, the amount of water available for dilution purposes at each of our three outlets has been approximately estimated. For the purpose of these studies, United States Coast Survey Chart No. 542 and the records of the United States Engineer Office were used in estimating the effective dilution. The amount of partially polluted water remaining in each channel at the beginning of the flood was determined and was added to the total discharge during the next tidal period. This process of summation was continued for a series of tides until the residual correction became so small as to be negligible. In this manner the ultimate dilution of sewage discharged at each of the three outfalls and the ultimate dilution of the entire discharge with reference to the entire tidal flow in and out of Jamaica Bay was determined. The sewage discharged into Rockaway Inlet from Riches Point Meadow, if considered alone, would have an ultimate dilution, determined as indicated, of one part in 2,670, but when considered together with the discharges into other portions of the bay, the ultimate dilution is one in 209. The discharge from concentration point "A" into the Big Fishkill Channel will have a similar ultimate dilution of one part in 75. Sewage discharged from concentration point "B" into Broad Channel will have a similar ultimate dilution of one part in 95. The final dilution of the combined flow from these three discharges into the waters of Rockaway Inlet will be one part in 209, as stated above. These figures are based upon an assumption of thorough diffusion, and at such times as slack water the percentage of pollution will be much greater.

In the course of our experiments, which have been carried on during the past eight months, we have determined, among other things, the amount of oxygen which the sewage of Brooklyn as it now runs to the East New York Pumping Station will absorb from aerated water. The full details of these experiments will be reported upon in a special report. For our present purposes it may be stated that the oxidizability of the sewage in question, or its capacity for absorbing oxygen from the water with which it is mixed varies greatly during the season, being greatest in the summer time and least in the winter. One million gallons of the sewage, if diluted in 100 million gallons of sea water, will, in the course of twelve hours, ab-

sorb from the water about 1,950 pounds of oxygen, under conditions which exist during three months in the summer. During the remainder of the year the absorption averages about 500 pounds per million gallons. Obviously it is necessary to provide for the extreme conditions of summer. Under these same conditions the water of the outer bay may be assumed to have a temperature of about 17 degrees C., and a corresponding oxygen content of
139 66.8 pounds per million gallons. In this case it will be safe to allow a reduction of this oxygen to at least 75 per cent of the full saturation value, giving us 25 per cent, or 16.7 pounds of oxygen per million gallons of water available for purposes of oxidation; a reduction in the oxygen value to less than 50 per cent of saturation is almost sure to result in a nuisance, and as we are dealing here with average conditions, it is believed wise to base our calculations upon a reduction to about 75 per cent, thus allowing a margin of safety for fluctuating conditions of sewage flow and tide. Our fundamental data under extreme summer conditions are, therefore:

(1) One million gallons of crude sewage will absorb 1,950 pounds of oxygen in 12 hours, or one tidal period.

(2) One million gallons of sea water contain 16.7 pounds of oxygen which is available for purposes of oxidation.

With this data it is a simple matter to determine the limiting dilution of 1 in 117, above which it is not safe to go.

One other possible source of oxygen suggests itself, namely, absorption from the atmosphere. This phenomenon of absorption or reaeration undoubtedly exists, but a careful study of its quantitative aspects has convinced us that it has little practical value under the conditions with which we have to deal.

It is obvious, therefore, that with the full development of this drainage system some means will have to be utilized to reduce the oxidizability of the sewage before discharge.

The oxidizability referred to above was obtained from the crude sewage as it is now received at the pumping station. There can be little doubt but that some comparatively simple screening will reduce the figure somewhat, so that ultimate dilutions of 1 in 100 may be possible.

For a further reduction in oxidizability some form of purification will be found necessary. Our experiments have proceeded far enough to enable us to state at this time that by a simple and cheap process of aeration the oxygen requirements of the sewage can be reduced at least one-half, and probably, under summer conditions, two-thirds. In other words, this sewage which will now absorb 1,950 pounds of oxygen per million gallons in 12 hours, can by some such process as we shall fully describe later, be so altered that it will absorb not more than 975, and possibly not over 650 pounds. This will make dilution of 1 in 50, or less, permissible, and obviate entirely the necessity for further purification of sewage by filters.

We are prepared to recommend, therefore, that at Riches Point Meadow concentration point, and at both concentration points "A" and "B," provision be made for screening and aerating the sewage

before discharge. Details of the aeration process will be given in a subsequent report. This treatment will probably not be necessary until the proposed drainage system has been developed to at least one-half of its ultimate capacity. After that time it will be necessary to employ the aeration process only during certain of the summer months, and at ultimate development such employment will probably not exceed four months of the year. These facts have an important bearing on the consideration of the ultimate cost of treatment.

140 The discharge into Little Neck Bay is necessarily into shoal water near the head of a land-locked bay in which practically the only circulation is that due to tidal flow. It is therefore impossible to make any accurate calculations of the dilution factor, but purification will evidently be required. We recommend at the start effective fine screening, a short period of sedimentation, and forced aeration. Our recommendation of the latter process is based upon experimental work which we have conducted during the summer at Brooklyn and at Boston. This work is not yet completed, but has gone far enough to enable us to state that in situations similar to the one under discussion an important reduction in the putrescibility of the sewage can be obtained in this manner and at reasonable costs.

The three outlets along the shore front of the Rockaway Section will each be carried about 1,000 feet off shore into water having a mean depth of 15 feet. Experience elsewhere, notably at Asbury Park and Ocean Grove, has indicated that with suitable provision for the removal of the grosser suspended matter, such a method of disposal may be used without any resulting nuisance. We recommend disposal work at these points, consisting of screening and a short period of detention in hydrolytic tanks, so designed as to clarify the sewage and give a maximum of liquefying action with a minimum of anaerobic putrefaction.

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

(Here follows map marked page 141, Complainants' Exhibit No. 136.)

142 *Special Report on the Richmond Drainage District.*

Submitted to the Board of Estimate and Apportionment March 9, 1911.

143 CHIEF ENGINEER'S OFFICE,
BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, March 4, 1911.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment:

SIR: Herewith is transmitted the report of Colonel William M. Black, U. S. A., and Professor Earle B. Phelps, bearing date of February 15, 1911, in the matter of the locations which might properly be selected for the discharge of sewage from the entire Borough of Richmond.

This report has been prepared pursuant to the instructions given by the Board in 1909, under which Colonel Black was requested to advise concerning the method which, in his judgment, might properly be adopted in order to most advantageously use the harbor waters for the removal of sewage, and has been prepared along the same lines as were followed in investigating the Corona, Flushing, and Jamaica districts of the Borough of Queens, in each of which sections it was found necessary to outline a general plan for the drainage of the entire area affected in order to establish the practicability of using the points selected for outlet.

The report now submitted completes the investigation in so far as it relates to the portions of the City for which no complete drainage plan has yet been prepared.

The investigation was also made to include a study of the circulation of fresh and polluted water in the harbor, with a view of determining the amount of sewage which could properly be admitted in various sections, together with the results of experimental work concerning a new process of purification which it was believed might be employed with advantage. The results of the latter investigation are contained in another communication which will be made the subject of a separate report, this completing the entire work originally contemplated.

In this report it is pointed out that about 63 per cent. of the entire area of the Borough of Richmond is located on the northwesterly side of the backbone of the island and drains naturally into the Arthur Kill and the Kill von Kull, and that of the 36 miles of coast line about one-half borders upon the kills, neither of which can be considered as available for the discharge of crude sewage. It is also pointed out that the five miles of coast line bordering the upper bay are similarly unavailable for such use owing to the pollution to which they are already subjected, and that of the remaining thirteen miles having frontage upon the lower bay a considerable portion is unavailable for the discharge of sewage owing in part to the shallow

depth, and in part to the tidal circulation which would result in the return of discharged sewage to the bathing beaches. These conditions leave only the upper portion of the lower bay in the vicinity of the Narrows and the southerly portion of the island as the only sections along the coast line suited for the use under consideration unless purification is resorted to. The plan which has been outlined is intended to meet these conditions in so far as practicable and provides for the collection and discharge of sewage at seven points.

144 Two of these points are located in the vicinity of Fort Wadsworth, here outletting into the deep waters of the Narrows. At these two points there will be concentrated more than one-half of the total sanitary flow for the Borough, this being accomplished by bringing a portion of the sewage from the westerly water-shed southwardly through the gap at Richmond, thence returning along the easterly slope of the island.

The five remaining points are located respectively at Great Kills, Seguine's Point and Red Bank on the southerly side of the island, and at Lake's Island and Bloomfield on the Arthur Kill. At the last two mentioned points purification by sedimentation and forced aeration will be required.

It has been assumed that the island will have a population representing a density of about 25 persons per acre and that the dry weather flow will be equivalent to a water consumption of 125 gallons per capita per day, of which one-half would be discharged into the sewers in eight hours. In determining the size of sewers for the sanitary flow an allowance has been made for a seepage of ground water at a uniform rate of 0.003 cubic feet per second per acre. It has been assumed that the flow in the sewers will have a velocity of three feet per second, and that a minimum of six feet of cover will be provided.

In the studies no provision has been made for the removal of the storm flow, it being understood that this study was in no way connected with the investigation desired by the Board.

Owing to the low elevation of many of the areas affected it has been deemed necessary to make provision for eleven pumping stations at which the sewage would be elevated through heights varying from 6 feet upwards to 42 feet, requiring an aggregate of 525 horse-power. Provision is also made for six force mains having an aggregate length of about 18,900 feet.

The report includes tables giving the essential elements of the system as planned, which is also shown upon a general map which accompanies the report.

It is understood that owing in part to the absence of data on which a complete plan could be prepared, and in part to the fact that this investigation was intended to be limited simply to such work as was involved in establishing the practicability of carrying the drainage to the points selected for outlet that the plan is not offered as of other than of a suggestive character and that a more or less radical revision may be necessary in many particulars.

I would recommend that a copy of this report and of the accompanying map be transmitted to the President of the Borough of

Richmond with the suggestion that he be asked to give them careful consideration in the preparation of the drainage plans for this district.

Respectfully,

NELSON P. LEWIS,
Chief Engineer.

145 February 15, 1911.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, New York City, New York:

SIR: In connection with our general studies of the sewerage problem of certain portions of Greater New York, we submit herewith a report upon that portion of our work which deals with the Borough of Richmond, and which, in accordance with our previous practice, we will term "The Richmond Drainage District."

Physical Features.

Physically, the Borough of Richmond, or Staten Island, is not well suited for an economical design of a comprehensive drainage system. Although presenting bold slopes and favorable grades in many cases, in others, flat, marshy tracts render the collection of sewage by gravity extremely difficult. Again, the ridges and hills which produce the favorable slopes in some places, offer a most effective barrier to the outlet of the sewage when once collected, except by long detours and consequent loss of elevation, or by still more expensive processes of tunneling.

The island drains naturally in two directions; to the east, or towards the Lower Bay, where tidal circulation is excellent, the water is constantly renewed by influx from the unpolluted supply of the Atlantic Ocean, and the capacity for sewage reduction is almost unlimited; and to the west, or towards the Arthur Kill, where tidal circulation is poor, the water merely rising and falling without greatly changing on each tide, and where it is reported that in parts pollution from the various New Jersey rivers has already passed the stage of a nuisance.

The divide between these two watersheds consists of a pronounced ridge, running the entire length of and forming the backbone of the island. At the north end this ridge rises abruptly to a height of 200 feet and over, continuing south with steep slopes on either side, and increasing gradually in elevation to over 400 feet at a distance of about four miles from the upper end. Two miles farther south the ridge drops suddenly to the lowest point of its entire length, and rises again, but more gradually, forming a gap at an elevation of about 50 feet. From this gap, which plays an important part in the design hereinafter proposed, the ridge continues irregularly to the southern end of the island, averaging only about 100 feet in height, and nowhere rising above 150 feet.

The total length of the island is about thirteen miles, and its greatest width about eight miles. The area is over 57 square miles,

or 36,623 acres, of which 13,584 acres, or 37 per cent., lie in the eastern watershed, and 23,039 acres, or 63 per cent., in the western watershed, which drains naturally into the already polluted kills.

146 In the upper part of the island, and bordering upon the Arthur Kill, are extensive swamp areas, aggregating about 6,461 acres below the 10-foot contour.

The length of coast line is 36 miles, of which 18 miles, or 50 per cent., border upon the kills, and are not available for the discharge of untreated sewage, 5 miles upon the Upper Bay, which is already greatly burdened by the sewage from the East and Hudson Rivers and the Kill von Kull, and will soon feel the effects of the New Passaic Valley outlet, which leaves barely 13 miles, or 36 per cent. of the total perimeter, bordering upon the Lower Bay, where raw sewage may be safely discharged. Again, certain points only of this coast are available for discharge, as the water is shoal and prevents good tidal circulation in a number of places. At the Narrows, discharge is safe if carried out to deep water in the channel; below this, at the beaches, everything discharged returns upon the shore, so that no outfalls are permissible in this vicinity. The lower half of this coast, however, embracing the stretch between Great Kills and the southern extremity of the island, is shown by the United States Coast Survey charts to have a channel parallel to the shore, into which sewage may be discharged with a reasonable certainty of its being carried away by the tidal currents.

Division Into Drainage Areas.*

The island is divided into nine main divisions, lettered A to I, inclusive, as explained in the succeeding paragraphs, and each division is further divided into several drainage areas, numbered 1 to 85, inclusive, for the entire island. The locations of these areas are as follows:

Division A, Areas 1-9.

This comprises the area lying on the western slope of the ridge and tributary to the Kill von Kull, extending westward to the low land bordering upon the Arthur Kill.

Area 1 comprises Districts 17 (*a*), 18 (*a*), and 19 (*a*) of the Sewer Department.

Area 2 comprises the valley extending inland from Port Richmond.

Area 3 is composed of that section of the north shore extending from Snug Harbor westward to Port Richmond.

NOTE.—Areas 1-3 require a low-level system, the flow from which will be concentrated at the Shore road (Richmond terrace) and Columbia street, and pumped through a force-main along the latter to the gravity Interceptor at Post avenue.

Area 4 is a large tract lying upon the slope of the ridge, and extending from the crest down to the 50-foot contour.

* See map of Richmond Drainage District following p. 182.

Areas 5 and 6 occupy the head of the valley of Clove Brook, extending to the crest of the ridge.

Area 7 occupies the remaining portion of the valley around Richmond Lake and lying above the 40-foot contour.

Area 8 lies between Area 3 on the north and Area 6 on the south.

Area 9 lies at the junction of the line of the ridge with the shore.

Division B, Areas 10-17.

This comprises the area lying on the eastern slope of the ridge, above the Narrows, and tributary to the Upper Bay.

147 Areas 10, 11 and 12, occupy the extreme northeast corner of the island, 11 and 12 comprising Districts 1 (*a*) and 1 (D), respectively, of the Sewer Department.

Areas 13, 14 and 15 occupy the valley extending from Tompkinsville inland to the Fingerboard road.

Area 16 borders upon the Upper Bay, just above the Narrows.

Area 17 comprises the western shore of the Narrows, and includes the military reservation of Fort Wadsworth, which may at some future date connect with the sewerage system of the borough.

Division C, Areas 18-33.

This comprises the area lying on the western slope of the ridge, above the 50-foot contour, between Willow Brook on the north and Huguenot avenue on the south.

Areas 18, 19, 20 and 21 lie upon the western slope of the ridge, above the Gap, and in the order named from Willow Brook to Richmond Creek.

Areas 22 and 23 occupy the valley just west of the ridge and extending north from the Gap.

Areas 24 to 33 lie in an irregular semi-circle between the summit of the ridge and the low land bordering upon the Fresh Kills.

Area 24 lies at the western extremity of this semi-circle, near the Arthur Kill, and Area 33 at the eastern end, just south of the Gap.

Division D, Areas 34-46.

This comprises that area lying on the eastern slopes of the ridge, above the 40-foot contour, between the Narrows on the north and Great Kills on the south, including the low land back of South Beach.

Areas 34 and 35 occupy the eastern slope of the ridge, adjacent to the Gap, and between the summit and the low land around Great Kills.

Area 36 occupies the valley east of the ridge and north of the Gap.

Area 37 includes the village of New Dorp, lying at the mouth of the valley comprising Area 36.

Areas 38 and 39 lie upon the eastern slope of the ridge, back of Grant City.

Areas 40, 41 and 42 comprise the low land bordering upon the Lower Bay and extending from South Beach on the north to Elm Tree Beacon on the south.

Areas 43, 44, 45 and 46 lie, in the order named, upon the southern slope of the spur ridge extending from the main ridge to the Narrows.

Division E, Areas 47-51.

Areas 47 and 48 occupy the low land composing the western shore of Great Kills Bay.

Area 49 occupies the low ground extending from the head of Great Kills Bay back to the 50-foot contour.

Area 50 includes the low land north of Great Kills Bay and bordering upon the Lower Bay.

Area 51 constitutes the small peninsula which forms the eastern shore of Great Kills Bay.

148 Division F, Areas 52-58.

Areas 52, 53, 54 and 55 extend, in the order named, along the shore of the Lower Bay, from Great Kills on the north to Seguine's Point on the south.

Areas 56 and 57 occupy the head, and Area 58 the mouth, of the valley of Lemon Creek, which extends inland from the head of Princes Bay.

Division G, Areas 59-68.

This comprises the entire southern end of the island.

Areas 59, 60, 61, and 62 lie upon the shore of Arthur Kill, extending south from Smoking Point to Mill Creek.

Area 63 lies between the areas bordering upon Arthur Kill, and the summit of the ridge, north of Mill Creek.

Area 64 occupies the low land bordering upon the Arthur Kill, south of Mill Creek.

Area 65 lies south of Mill Creek, between the summit of the ridge and Area 64.

Area 66 lies upon the shore of Princes Bay.

Area 67 occupies the southern extremity of the island.

Area 68 lies upon the eastern slope of the ridge, about midway between Princes Bay and the southern extremity of the island.

Division H, Areas 69-79.

This comprises the low area tributary to the Fresh Kills and Arthur Kill.

Area 69 lies upon either side of Richmond Creek, just west of the Gap.

Areas 70, 71 and 73 occupy the south bank of Richmond Creek, extending, in the order named, from Area 69 towards the Arthur

Kill, and Area 72 lies between Area 71 and the summit of the ridge.

Area 74 lies upon the shore of the Arthur Kill, south of Fresh Kills.

Areas 75, 76 and 77 occupy the low ground east of Fresh Kills Creek, lying below the 50-foot contour, extending, in the order named, from the head of the creek to the fork of Fresh Kills.

Area 78 lies on the coast of Arthur Kill, north of Fresh Kills.

Area 79 comprises Lakes Island, at the mouth of Fresh Kills.

Division I, Areas 80-85.

Areas 80 and 81 occupy the coast of Arthur Kill, opposite the mouth of the Rahway River, New Jersey, and Pralls Island, respectively.

Areas 82 and 83 occupy the valley of Old Place Creek.

Area 84 occupies the extreme northwestern corner of the island, at the opening of the Arthur Kill into Newark Bay.

Area 85 lies upon the shore of Arthur Kill, between the mouth of Old Place Creek on the north, and Pralls Island on the south.

The acreage and estimated future populations of these 85 drainage areas are tabulated below. The total area of the district is seen to be 36,623 acres and the total estimated future population 915,575.

149

Area.	Acres.	Assumed future "Equivalent population."	
		Per acre.	Total.
1	336	25	8,400
2	1,085	25	27,125
3	339	25	8,475
4	1,235	25	30,875
5	555	25	13,875
6	311	25	7,775
7	474	25	11,850
8	603	25	15,075
9	411	25	10,275
10	277	25	6,925
11	108	25	2,700
12	95	25	2,375
13	298	25	7,450
14	430	25	10,750
15	592	25	14,800
16	453	25	11,325
17	411	25	10,275
18	736	25	18,400
19	644	25	16,100
20	215	25	5,375
21	408	25	10,200
22	615	25	15,375
23	458	25	11,450
24	261	25	6,525
25	265	25	6,625
26	157	25	3,925
27	365	25	9,125
28	711	25	17,775
29	312	25	7,800
30	341	25	8,525

150

Area.	Acres.	Assumed future "Equivalent population."	
		Per acre.	Total.
31	405	25	10,125
32	107	25	2,675
33	180	25	4,500
34	250	25	6,250
35	294	25	7,350
36	482	25	12,050
37	307	25	7,675
38	98	25	2,450
39	71	25	1,775
40	642	25	16,050
41	499	25	12,475
42	681	25	17,025
43	398	25	9,950
44	301	25	7,525
45	238	25	5,950
46	133	25	3,325
47	279	25	6,975
48	302	25	7,550
49	511	25	12,775
50	739	25	18,475
51	161	25	4,025
52	440	25	11,000
53	342	25	8,550
54	498	25	12,450
55	695	25	17,375
56	545	25	13,625
57	265	25	6,625
58	552	25	13,800
59	713	25	17,825
60	471	25	11,775
61	198	25	4,950
62	322	25	8,050
63	436	25	10,900
64	291	25	7,275
65	193	25	4,825
66	388	25	9,700
67	339	25	8,475
68	470	25	11,750
69	340	25	8,500
70	318	25	7,950
71	87	25	2,175
72	324	25	8,100
73	186	25	4,650
74	755	25	18,875
75	654	25	16,350
76	695	25	17,375
77	568	25	14,200
78	915	25	22,875
79	120	25	3,000
80	408	25	10,200
81	630	25	16,750
82	817	25	20,425
83	606	25	15,150
84	845	25	21,125
85	618	25	15,450
Total	36,623	..	915,575

General Scheme of Sewerage for the District.

The proposed design takes advantage of the most favorable physical features, and attempts to reduce to a minimum the cost of overcoming the difficulties.

Items which add greatly to the expense of a sewer system are: pumping, purification, detours involving great length of line, and tunneling. In order to concentrate at points allowing safe discharge, a certain amount of pumping is necessary, but this item has been kept as low as possible consistent with the avoidance of outfalls where purification would be required, and no lifts are here contemplated on the main lines, except where a force-main outfall must be installed, so that, generally, the amounts lifted, as well as the lifts themselves, are small, and may be served by automatic pumping stations.

Where pumping to a point of safe discharge would cost in excess of the cost of partial purification, small works are contemplated to purify to such extent as will render discharge into the Arthur
151 Kill unobjectionable. Only such degree of treatment is required as will produce an effluent of sufficient stability to delay putrefaction until the larger reservoir of the Lower Bay is reached.

At the main points of discharge, at the Narrows and in the Lower Bay, no purification is considered necessary.

Some long detours will have to be made, to secure favorable grades and to avoid the necessity of tunneling, which expedient will not be necessary in this design. The detours which are required to secure an outlet at the Gap will be less expensive than a tunnel through the ridge at any other point, as the distance between low ground on either side is considerable except at the Gap.

Divisions A and B, Areas 1-17.

The proposed design is as follows:

The area west of the ridge and tributary to the Kill von Kull, back to the low land bordering upon the Arthur Kill, is drained by a gravity interceptor, No. 1, along the north shore, the lower ground being served by a low-level system, whose flow is lifted by pumping to the level of Interceptor I. This interceptor encircles the northern point of the island, and serves also that area east of the ridge and above the Narrows which is tributary to the Upper Bay. The Outfall is just above Quarantine, at the foot of Pennsylvania avenue. The area tributary to this system is 8,013 acres, and the estimated maximum discharge at the outfall is 81.95 second-feet.

Divisions C and D, Areas 18-46.

The area lying on the western slope of the ridge, above the fifty-foot contour, and extending from about Willow Brook on the north to Huguenot avenue on the south, is served by two gravity inter-

ceptors, Nos. II and III, which unite at the Gap. Interceptor II serves the area north of the junction, and Interceptor III that to the south. After the junction, the interceptor, now known as No. IV, crosses the ridge at the Gap and serves that portion of the eastern slope between Great Kills and the Narrows which lies above about the forty-foot contour. The low-lying area back of and including South Beach is also served by this system, the flow being lifted through a force-main to Interceptor IV, in order to prevent the fouling of the beaches which would result were the outfall placed in this vicinity. The final discharge is located just below the Narrows, in deep water off shore.

The area tributary to this system is 10,574 acres, and the estimated maximum flow at the outfall is 108.18 second-feet.

Division E, Areas 47-51.

The low-lying area in the vicinity of Great Kills Bay is concentrated by gravity at a point near the head of the Bay, and pumped out to sea.

The tributary area is 1,992 acres, and the discharge 20.39 second-feet.

Division F, Areas 52-58.

The area on the eastern slopes of the ridge, lying between Great Kills on the north and Princes Bay on the south, most of which has a good elevation, is drained by Interceptor V to a concentration point at Seguine's Point, near the head of Princes Bay, and pumped Seaward.

The tributary area is 3,337 acres, and the discharge 34.14 second-feet.

152 Division G, Areas 59-68.

The area on the western slopes of the ridge, lying between Smoking Point on the north and the southern extremity of the island, is concentrated by Interceptor VI, with one relay lift for that portion north of Kreischerville, at a pumping station on Mill Creek, whence it is pumped through a force-main to a continuation of the gravity interceptor at the summit of the ridge. From this point the discharge is by gravity into the deep water off shore.

The area tributary to the gravity system of this division is 2,624 acres, and the maximum discharge is 26.84 second-feet.

The low level portion of this Division consists of the area lying on the eastern slope of the ridge, between Princes Bay and the southern end of the island, whose flow is collected by gravity at Red Bank, and lifted to the gravity outfall, by pumping.

The area tributary to this low level system is 1,197 acres, and the discharge is 12.25 second-feet.

The total area of Division G is 3,821 acres, and the discharge is 39.09 second-feet.

Division H, Areas 69-79.

The low, marshy area adjacent to the Fresh Kills, and tributary to the Arthur Kill, is served by two interceptors, Nos. VII and VIII, draining, with one relay lift in each, the areas south and north, respectively, of Fresh Kills and Richmond Creek. Both interceptors concentrate at the same point on Lakes Island, at the mouth of Fresh Kills, where the sewage will be purified sufficiently to permit its discharge into Arthur Kill without nuisance.

The tributary area is 4,962 acres, the discharge 50.75 second-feet.

Division I, Areas 80-85.

The flow from the low area occupying the northwestern corner of the island, and tributary to the Arthur Kill, will be concentrated by a gravity interceptor, No. IX, at a point on the shore of the Arthur Kill, north of Pralls Island, where it will be partially purified and finally discharged into Arthur Kill.

The tributary area is 3,924 acres, and the discharge 40.13 second-feet.

Trunk sewers are designated in general by the number of the area served. Their locations are as given in the following summary a study of which will be facilitated by reference to the accompanying map. The division lines between areas are indicated by heavy dotted lines, the sewers in solid red lines. Other devices used are sufficiently explained in the legend. Contours are at 20-foot intervals.

Division A.

1. From 1,000 feet west of South avenue, east along Shore road (Richmond terrace), to junction with Trunk 2 at Lafayette avenue.

2. From near Richmond turnpike, north, nearly parallel to Port Richmond road and Richmond avenue, to junction with Trunk 1 at Shore road (Richmond terrace).

1-2. Along Shore road (Richmond terrace), from Lafayette avenue to Columbia Street Pumping Station.

153 3. From Bard avenue, west along Richmond terrace to Columbia Street Pumping Station.

1-2-3. Columbia Street Force-main. From Columbia Street Pumping Station, at Richmond terrace, south along Columbia street to Interceptor I. at Post avenue.

4. From near Ocean Terrace road, at summit of the ridge, west down valley of stream to about 50-foot contour; thence along latter to junction with Columbia Street Force-Main at Columbia street and Post avenue.

5. From near summit of ridge, north along valley of stream to junction with Trunk 6 at Schœnian Pond.

5-6. From Junction of Trunks 5 and 6, north along valley of Clove Brook to Richmond Lake.

7. No trunk has been designed for Area 7, the flow from which will be considered as entering Trunk 5-6 at Richmond Lake.

5-6-7. From Richmond Lake, north along valley of Clove Brook to Interceptor I at Post avenue and Columbia street.

8. From near summit of ridge, northwest along valley of stream, to Castleton avenue, along Castleton avenue, Rement avenue to Interceptor I at Henderson avenue.

9. From summit of ridge, north along Lafayette avenue to Interceptor I. at Richmond terrace.

Division B.

10. From near summit of ridge, north along Richmond turnpike and Jersey street to Interceptor I. at Richmond terrace.

11. No trunk has been designed for Area 11, as this area is already sewered, and its trunk will be intercepted at Church street and Richmond terrace.

12. No trunk has been designed for Area 12, as this area is already sewered, and its trunk will be intercepted at Arietta street and Central avenue.

13. From junction of Fingerboard and Richmond roads, north along valley of stream to De Kalb avenue.

14. No trunk has been designed for Area 14, the flow from which will be considered as entering Trunk 13 at De Kalb avenue.

13-14. From De Kalb avenue, north along Danube avenue, Simonson place and Targee street to Laurel avenue.

15. No trunk has been designed for Area 15, the flow from which will be considered as entering Trunk 13-14 at Targee street and Laurel avenue.

13-14-15. From Targee street, along Laurel avenue, Gordon, Broad and Canal streets to Interceptor I. at Riker street.

16. From Grasmere Lake, north and east to Interceptor I. on Willow avenue.

17. From high ground back of Fort Wadsworth, east and north along Fingerboard road and New York avenue to junction with Interceptor I. at Pennsylvania avenue.

Division C.

18. From about 300-foot contour, on Manor road, west down valley of Willow Brook to near Willow Brook road; thence southwest to Interceptor II. at Rockland avenue, on 50-foot contour.

154 19. From about 220-foot contour, at Manor road, west down valley of Springville Creek to junction with Trunk 18 at 50-foot contour.

20. From about 140-foot contour, near Forest Hill avenue, west and south to Interceptor II, south of Richmond Hill road.

21. From about 130-foot contour, near crest of small ridge, south along valley of stream to Interceptor II.

22. From 300-foot contour, near Egbert avenue, south down valley of Richmond Creek to 100-foot contour on Saw Mill road.

23. No trunk has been designed for Area 23, the flow from which will be considered as entering Trunk 22 at the 100-foot contour on Saw Mill road.

22-23. From 100-foot contour, on Saw Mill road, south along valley of Richmond Creek, to Interceptor II. at Richmond.

24. From about 100-foot contour, near Huguenot avenue, north and east to junction with Trunk 25 at 50-foot contour, north of Washington avenue.

25. From 120-feot contour, along Washington avenue and valley of small stream to Interceptor III. at 50-foot contour.

26. From near Fresh Kills road, south along Greenridge avenue to Interceptor III.

27. From about 140-foot contour, near Huguenot avenue, east and north along valley of small stream to junction with Trunk 27-28 at Washington avenue.

28. No trunk has been designed for Area 28, the flow which will be considered as entering Trunk 27 at Washington avenue.

27-28. From junction of Trunks 27 and 28, east and north to Interceptor III.

29. From 80-foot contour, Woods of Arden, northeast, parallel to railroad to Wilson avenue; thence west along valley of stream to junction with Trunk 30 at about 50-foot contour.

30. From 60-foot contour, at Gifford's, south to Trunk 29.

29-30. From junction of Trunks 29 and 30, along valley of small stream to Interceptor III.

31. From 60-foot contour, north of Gifford's lane, west to Interceptor III.

32. From 80-foot contour, north along valley of small stream to Interceptor III.

33. From near summit of ridge, south of Gap, to Interceptor IV. at Gap.

Division D.

34. From Great Kills north, parallel to railroad, to junction with Trunk 35 at Clark avenue.

35. From 80-foot contour, east on Clark avenue to Trunk 34.

34-35. From junction of Trunks 34 and 35, north, parallel to railroad, to Interceptor IV. at Amboy road.

36. From 340-foot contour, on Todt Hill road, south along valley of creek to junction with Trunk 37 at Sixth street and Elm avenue, New Dorp.

155 37. From 140-foot contour, near New Dorp Beacon, east and south down valley of stream, along Grand avenue, Richmond road, Amboy road, Ocean avenue and Sixth street to Trunk 36 at Elm avenue.

36-37. From junction of Trunks 36 and 37 at Elm avenue, along prolongation of Elm avenue to Interceptor IV. on prolongation of Tenth street.

38. From Central avenue, along Richmond road and Barton avenue to Interceptor IV. at 30-foot contour.

39. From Jackson avenue, north along Richmond road, and east along Liberty avenue to Interceptor IV. at 30-foot contour.

40. From about 20-foot contour, near New Dorp lane, north and east to junction with Trunk 41 at New Creek.

41. From near railroad, Dongan Hills, east to Trunk 40.

40-41. From junction of Trunks 40 and 41, north to Sea View avenue Pumping Station.

42. From South Beach, south, parallel to shore, to Sea View Avenue Pumping Station.

40-41-42. Sea View Avenue Force-Main. From Sea View Avenue Pumping Station west along Sea View avenue to Interceptor IV. at 30-foot contour.

43. From 300-foot contour, near Ocean Terrace road, at summit of ridge, east down valley of stream to Interceptor IV. at 30-foot contour.

44. From 100-foot contour, near Grasmere, south along valley of stream and Parkinson avenue to Interceptor IV.

45. From 100-foot contour, on Fingerboard road, east and south along Fingerboard road and Sand Lane road to Interceptor IV.

46. From about 100-foot contour, south along Sea avenue to Interceptor IV. at Old Town avenue.

Division E.

47. From 60-foot contour, on Nelson avenue, southeast along Nelson avenue, nearly to shore of Great Kills Bay; thence following shore to junction with Trunk 48.

48. From 60-foot contour, along valley of small stream to Trunk 47, near shore of Great Kills Bay.

47-48. From junction of Trunks 47 and 48, northeast to junction with Trunk 49 at Mill Pond, near head of Great Kills Bay.

49. From 40-foot contour, near railroad at Courthouse, east and south along stream to Trunk 47-48 at Mill Pond.

47-48-49. From junction of Trunk 47-48 with Trunk 49, at Mill Pond, east to Great Kills Pumping Station.

50. South along shore from Elm Tree Beacon to Great Kills Pumping Station.

51. North along Great Kills Peninsula to Great Kills Pumping Station.

47-51. Outfall Section. From Great Kills Pumping Station, southeast to water 12 feet deep, 5,000 feet off shore.

Division F.

52. From 60-foot contour, opposite mouth of Great Kills Bay, south to shore, following shore southwest to junction with Trunk 53 at Barclay avenue.

156 53. From 60-foot contour, near Amboy road, south along small stream, parallel to Barclay avenue to junction with Trunk 52.

54. From 80-foot contour, near railroad, following valley of small

stream south to junction with Interceptor V. at Latourette's Pond, near shore.

55. From 100-foot contour, south along valley of stream, to junction with Interceptor V. at Wolfs Pond, near shore.

56. From 120-foot contour, near Wood Row, west and south to junction with Trunk 57, at Maguire avenue, near fork of Lemon Creek.

57. From 100-foot contour, west and south to junction with Trunk 56, at Maguire avenue, near fork of Lemon Creek.

56-57. From junction of Trunks 56 and 57, south and east along valley of Lemon Creek, to a point nearly opposite Findlay avenue.

58. No trunk has been designed for Area 58, the flow from which will be considered as entering Trunk 56-57 at a point opposite Findlay avenue.

56-57-58. From bend in Lemon Creek, opposite Findlay avenue, along valley of Lemon Creek, to Seguine's Point Pumping Station.

Division G.

59. From Rossville, west and south along shore of Arthur Kill to Kreischerville Relay Pumping Station, at junction with Trunk 60, at mouth of stream opposite Boynton Beach, New Jersey.

60. From 100-foot contour, near Pleasant avenue, west along valley of stream to Kreischerville Relay Pumping Station, at junction with Trunk 59.

61. From 100-foot contour, west to south end of Kreischerville Force-main.

62. From 80-foot contour, south to Interceptor VI., near Mill Creek.

63. From about 100-foot contour, south of Sharrott's road, south and west to Interceptor VI., at junction with Trunk 62.

64. From near Hopkins avenue, Tottenville, north along shore of Arthur Kill to Mill Creek Pumping Station.

65. From 60-foot contour, near summit of ridge, along valley of Mill Creek to Mill Creek Pumping Station.

66. From 40-foot contour, near summit of ridge, south to shore of Prince's Bay; following shore southwest to Red Bank Pumping Station.

67. From near Bay Cliff Lake, at summit of ridge, south to shore, near southern extremity of island; northeast along shore to junction with Trunk 68 at Central avenue.

68. From summit of ridge, near 60-foot contour, south along Central avenue, to junction with Trunk 67 at shore.

67-68. From Central avenue, northeast along shore to Red Bank Pumping Station.

Division H.

69. From near Fresh Kills road, following line of Richmond Creek, to Richmond Creek Pumping Station, near Fresh Kills Bridge.

70. From 10-foot contour, near Eltingville road, east and north to Richmond Creek Pumping Station.

157 71. From 20-foot contour, near Greenridge avenue, and Fresh Kills road, northeast to west end of Richmond Creek Force-main, near bend in Richmond Creek.

72. From 40-foot contour, near Washington avenue, north along valley of small stream, to junction with Trunk 73, about 2,000 feet from Fresh Kills.

73. From spur of ridge, west of Trunk 72.

72-73. From junction of Trunks 72 and 73, north to Interceptor VII., near fork of Fresh Kills.

74. From 40-foot contour, near Fresh Kills road, and Huguenot avenue, north, parallel to shore of Arthur Kill, to junction with Interceptor VII. on Fresh Kills, opposite Lake's Island.

75. From about 40-foot contour, at Willow Brook, following the Brook and east shore of Fresh Kills Creek, west and south to junction with Trunk 76 at mouth of Springville Creek.

76. From near 40-foot contour, on Rockland avenue, following Springville Creek west to Fresh Kills Creek.

77. From 20 foot contour, near Old Turnpike, south along valley of stream, and west along Richmond Creek to Fresh Kills Pumping Station.

78. From Union avenue, southwest, generally parallel to Fresh Kills Creek, to west end of Fresh Kills Force-main.

79. No trunk has been designed for Area 79, but its flow will drain directly into the pump-well of the Lakes Island Pumping Station.

Division I.

80. From near Union avenue, west along valley of Neck Creek to shore, following shore north to junction with Trunk 81 at mouth of small creek, opposite Pralls Island.

81. From 10-foot contour, west along valley of creek to Trunk 80.

80–81. From junction of Trunks 80 and 81, north along shore of Arthur Kill to Bloomfield Purification Works, at a point north of Pralls Island.

82. From 10-foot contour, near Simonson avenue, west along valley of Old Place Creek to junction with Trunk 83.

83. From 10-foot contour, near Decker avenue, north to Trunk 82 at Old Place Creek.

84. From 10-foot contour, near South avenue, west along Bridge Creek to Western avenue, southwest to Old Place road, across Old Place Creek to Junction with Interceptor IX.

85. From near mouth of Old Place Creek, south along shore of Arthur Kill to Bloomfield Purification Works.

Design of Trunk Sewers from Each Area.

The daily flow of sewage has been assumed as equal to the water consumption, and for lack of more definite information, this latter figure has been taken at 125 gallons per capita per day.

Sewers are in all cases designed for maximum sanitary flow, as determined from the assumed future population and per
158 capita water consumption. No allowance has been made for storm flow in this district. Ground water is taken uniformly at 0.003 second feet per acre.

Future population has been assumed as suburban in character, with a density of 25 persons per acre, uniformly distributed over the entire district.

For the peak load upon the system, the maximum flow is assumed to be at a rate which would carry off half the daily flow in eight hours.

Trunks and branches, in which the flow is apt to vary greatly from the assumed maximum, owing to the comparatively small areas served, and liability to local influences, have been designed to carry the assumed maximum flow when only half full, in order to provide for contingencies, while the interceptors, in which the flow will equalize and be much more uniform, have been designed to carry the assumed maximum flow when eight tenths full.

The design for size, grade, etc., has been made from the diagrams in Swan & Horton's "Hydraulic Diagrams," and from a diagram of hydraulic elements for circular sections, in the same book, the discharges and velocities for the sewers 0.8, 0.5, 0.2 and 0.1 full, have been computed.

Except in very few cases, the grades have been taken so as to insure a velocity of 3.0 feet per second or greater, which will give a velocity of 1.8 feet per second when flowing 0.2 full, or at only 0.085 full discharge. This velocity is thought to be sufficient for self-cleansing purposes.

In all siphons, force-mains and outfalls, an effort has been made to secure a uniform velocity of 3.0 feet per second, as nearly as commercial sizes of cast iron pipe will permit.

All designs contemplate circular sections only.

The datum plane for all elevations is the plane of Mean Sea Level at Sandy Hook, as established by the U. S. Coast and Geodetic Survey.

When elevations are given, they refer invariably to the invert of the sewer, unless otherwise specifically stated.

In all cases where the depth of a sewer is mentioned, the depth to the inner top is meant; i. e., the depth to the invert, less the diameter.

In all possible cases, an earth covering of six feet over the inner top of the sewers has been allowed. In no case has this covering been reduced to less than four feet.

Wherever possible, the grades have been taken so as to fit the slope of the ground, but where this would give velocities in excess of about 7.5 feet per second, or where a portion of the ground has a slope flatter than the remainder, a flat grade has been adopted, and the sewer left at a uniform depth of about four to six feet by drop manholes installed at convenient intervals.

At the low-lying portions of the Borough, it is assumed that the

finished grade of the surface, behind the bulkhead wall, will be about 7.35 feet above the datum of Mean Sea Level, or 5.0 feet above Mean High Water (Dock Department).

Whenever possible, at the junction of a trunk with an interceptor the invert of the former is elevated above that of the latter by an amount equal to the difference of diameter, or by half the diameter of the interceptor, if the difference of diameter exceeds this. This is done in order to preserve an unbroken invert in the interceptor, and thus prevent eddies and consequent deposits of suspended solids, and to prevent backing up into small trunks. This
159 elevation is not given where two trunks unite to form an interceptor, nor, obviously, where the two sewers are of the same diameter.

Where an existing storm sewer is intercepted, the interceptor is designed to take only the dry weather flow, and the remaining length of the storm sewer will be maintained and utilized as a storm overflow, to prevent choking of the interceptor.

In the following table are summarized the principal elements involved in the design of these trunk sewers, namely, length, total fall, elevation of invert at upper end, tributary area, slope, maximum diameter, maximum discharge, and velocities and discharges at 0.8 and at 0.2 full.

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Tributary area, acres.	Slope 1, foot in—	Maximum diameter, feet.	Maximum discharge, sec. ft.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
A—											
1											
Sec. 1	5,000	10.00	2.40	336	500	1.83	3.44	2.88	6.74	1.50	0.59
Sec. 2	4,770	9.54	7.04	336	500	1.83	3.44	2.88	6.74	1.50	0.59
2	12,800	32.00	24.40	1,085	400	2.75	11.10	4.37	17.75	2.28	1.80
1-2	3,900	4.40	−7.60	1,421	900	3.50	14.54	3.45	28.50	1.80	2.48
3	6,470	16.18	4.18	339	400	1.83	3.47	3.22	6.80	1.68	0.59
1-3	†										
4	13,850	108.00	229.65	1,275	70	3.17	12.63	8.51	24.77	4.44	2.15
5	5,280	52.80	387.85	555	100	1.67	5.68	6.10	11.11	3.18	0.97
6	4,300	87.40	222.45	311	50	1.25	3.18	6.67	6.24	3.48	0.54
5-6	4,220	21.10	135.05	806	200	1.75	8.80	4.60	8.80	2.40	0.77
7	†										
5-7	3,700	82.30	133.95	1,340	45	1.67	13.70	8.63	13.70	4.50	1.19
8	7,920	79.20	101.62	693	100	1.75	6.17	6.10	12.10	3.18	1.05
9	5,020	125.40	147.23	411	40	1.25	4.20	7.83	8.23	4.08	0.72
B—											
10	7,000	140.00	100.45	277	50	1.17	2.84	6.44	5.57	3.36	0.48
11	†										
12	†										
13	3,300	11.00	96.03	208	300	1.67	3.05	3.45	5.98	1.80	0.52
14	†										
13-14	4,480	42.00	85.03	728	105	1.50	7.45	5.40	7.45	2.82	0.65
15	†										
13-15	2,770	39.80	42.43	1,320	90	1.75	13.50	6.67	13.50	3.48	1.17
16	4,800	85.10	95.01	453	57	1.50	4.63	7.01	9.07	3.66	0.79
17	5,150	49.05	56.53	411	105	1.50	4.20	5.53	8.24	2.88	0.71
C—											
18	11,350	180.20	230.37	736	60	1.67	7.53	7.94	14.75	4.14	1.28
19	5,940	118.80	159.97	644	50	1.67	6.59	8.65	12.91	4.20	1.12
20	3,300	91.60	120.83	215	36	1.00	2.20	6.80	4.31	3.54	0.37

21	7,260	85.40	115.52	408	85	1.50	4.17	5.87	8.17	3.00	0.71
22	8,710	174.00	205.87	615	50	1.50	6.29	8.05	12.32	4.20	1.07
101											
23	†	....	....	....	....	....	....	....	....	....	....
22-23	5,670	37.80	59.87	1,073	150	2.33	10.98	6.10	21.50	3.18	1.87
24	4,390	62.30	103.89	261	70	1.17	2.67	5.75	5.23	3.00	0.45
25	2,240	64.00	105.59	295	35	1.17	2.71	7.25	5.30	3.78	0.46
26	2,110	11.40	40.78	157	185	1.17	1.61	3.45	3.16	1.80	0.27
27	7,000	63.70	122.77	365	110	1.50	3.74	5.18	7.33	2.70	0.64
28	†	....	....	....	....	....	....	....	....	....	....
27-28	5,680	31.55	59.07	1,076	180	2.50	11.01	5.75	21.60	3.00	1.87
29	5,020	29.56	68.50	312	170	1.50	3.19	4.28	6.25	2.22	0.54
30	2,510	8.37	47.31	341	300	1.75	3.49	3.45	6.84	1.80	0.59
29-30	3,040	10.12	38.94	653	300	2.17	6.68	4.14	13.10	2.16	1.14
31	2,640	17.60	45.15	405	150	1.67	4.14	4.72	8.11	2.46	0.70
32	2,110	42.20	65.61	107	50	0.83	1.09	5.01	2.14	2.64	0.19
33	3,040	43.45	65.63	180	70	1.17	1.84	5.18	3.60	2.70	0.31
D—											
34	7,920	28.80	53.70	250	275	1.50	2.56	3.45	5.02	1.80	0.44
35	1,450	41.45	66.35	294	35	1.17	3.01	7.48	5.90	3.90	0.51
34-35	2,510	5.58	24.90	544	450	2.17	5.57	3.45	10.91	1.80	0.95
36	9,040	192.50	220.27	482	50	1.50	4.94	7.48	9.68	3.90	0.84
37	5,940	59.40	87.17	397	100	1.50	3.14	5.75	6.15	3.00	0.53
36-37	660	11.00	27.77	780	60	1.75	8.08	8.05	15.83	4.20	1.37
38	2,380	36.62	51.33	98	65	0.83	1.09	4.49	1.91	2.34	0.17
39	2,640	37.75	50.97	71	70	0.75	0.73	4.62	1.43	2.10	0.12
40	8,580	25.24	16.73	642	340	2.17	6.57	4.03	12.89	2.10	1.12
41	5,280	12.42	3.91	490	425	2.17	5.10	3.45	10.00	1.80	0.87
40-41	1,100	1.49	—8.51	1,141	800	3.17	11.67	3.45	22.85	1.80	1.98
42	6,600	11.00	1.00	681	600	2.50	6.97	3.45	13.67	1.80	1.19
40-42	*	....	....	....	....	....	....	....	....	....	....
43	5,940	109.70	182.60	398	35	1.25	4.07	8.05	7.96	4.20	0.69
44	2,640	75.50	86.41	201	35	1.17	2.08	7.47	6.05	3.90	0.52
45	3,850	76.60	85.75	238	50	1.17	2.43	6.20	4.76	3.24	0.41
46	1,980	79.30	87.57	133	25	0.83	1.36	6.90	2.66	3.60	0.23

*Force main. †No trunk designed.

Trunk No.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Tributary area, acres.	Slope 1, foot in—	Maximum diameter, feet.	Maximum discharge, sec., ft.	Sewer 0.8 full. Velocity, sec., ft.	Sewer 0.8 full. Discharge, sec., ft.	Sewer 0.2 full. Velocity, sec., ft.	Sewer 0.2 full. Discharge, sec., ft.
E—											
47	6,600	22.00	23.87	279	300	1.67	2.86	3.45	5.61	1.80	0.49
48	2,640	8.80	10.67	302	300	1.67	3.09	3.45	6.06	1.80	0.53
47-48	2,770	9.23	1.87	581	300	1.67	5.95	3.45	5.95	1.80	0.52
49	6,070	8.68	1.32	511	700	2.33	5.23	2.88	10.25	1.50	0.89
47-49	1,320	2.64	—7.36	1,092	500	2.25	11.18	3.45	11.18	1.80	0.97
50	8,580	14.30	4.30	739	600	2.67	7.56	3.45	14.81	1.80	1.29
51	5,940	14.86	4.86	161	400	1.50	1.65	2.53	3.24	1.32	0.28
F—											
52	8,840	47.75	55.89	440	185	1.75	4.50	4.60	8.82	2.40	0.77
53	5,540	50.40	58.54	342	110	1.50	3.50	5.18	6.86	2.70	0.59
54	7,390	54.75	57.32	498	135	1.67	5.09	5.30	9.98	2.76	0.87
55	9,640	48.20	40.92	695	200	2.17	7.11	4.84	13.94	2.52	1.21
56	7,660	95.90	107.75	545	80	1.67	5.58	6.55	10.93	3.42	0.95
57	5,020	77.25	89.10	265	65	1.17	2.71	5.75	5.30	3.00	0.46
56-57	3,430	17.15	11.85	810	200	2.17	8.29	5.18	16.24	2.70	1.41
58	†.....	.....	.....	...	...	....	....	....	....	....	....
56-58	4,220	4.70	—5.30	1,362	900	3.50	13.94	3.45	27.30	1.80	2.37
G—											
59	10,560	19.20	7.20	713	550	2.50	7.29	3.45	14.29	1.80	1.24
60	7,130	57.00	45.00	471	125	1.67	4.82	5.30	9.45	2.76	0.82
61	2,640	88.00	90.02	198	30	1.00	2.03	7.02	3.98	3.66	0.36
62	3,830	47.90	39.54	322	80	1.33	3.29	5.75	6.45	3.00	0.56
63	8,580	90.40	81.87	436	95	1.50	4.46	5.75	8.74	3.00	0.76
64	7,200	14.52	4.52	291	500	1.75	2.98	2.88	5.84	1.50	0.51
65	3,300	60.00	50.00	193	55	1.17	1.97	5.75	3.86	3.00	0.34
66	6,860	22.90	12.90	388	300	1.83	3.97	3.68	7.78	1.92	0.68
67	7,390	18.45	13.95	339	400	1.83	3.47	3.22	6.80	1.68	0.59
68	4,220	52.80	48.30	470	80	1.50	4.81	6.22	9.44	3.24	0.82
67-68	3,300	5.50	—4.50	809	600	2.67	8.28	3.45	16.22	1.80	1.41

H—											
69	6,070	12.13	2.13	340	500	2.00	3.48	2.88	6.82	1.50	0.59
70	3,830	11.95	1.95	318	320	1.67	3.25	3.45	6.37	1.80	0.55
71	1,580	13.73	17.09	87	115	1.00	0.89	3.45	1.74	1.80	0.15
72	6,730	13.45	10.95	324	500	1.83	3.31	2.88	6.48	1.50	0.56
73	1,980	9.90	7.40	186	200	1.33	1.90	3.45	3.72	1.80	0.32
72-73	1,450	3.22	—2.50	510	450	2.17	5.21	3.45	10.20	1.80	0.89
74	8,450	14.08	4.75	755	600	2.67	7.72	3.45	15.13	1.80	1.31
75	11,880	13.20	9.36	654	900	2.67	6.69	2.88	13.11	1.50	1.14
76	6,340	7.04	3.20	695	900	2.75	7.11	2.88	13.93	1.50	1.20
77	8,710	17.42	7.42	568	500	2.25	5.81	3.45	11.38	1.80	0.99
163											
78	7,520	7.52	0.48	915	1,000	3.17	9.36	2.88	18.36	1.50	1.59
79	†.....	....	....	...	...	....	....	....	....	....	....
I—											
80	8,700	14.50	5.47	408	600	2.17	4.17	2.88	8.17	1.50	0.71
81	5,680	11.34	2.31	630	500	2.33	6.44	3.45	12.61	1.80	1.09
80-81	3,560	2.97	—9.03	1,038	1,200	3.33	10.61	2.88	20.80	1.50	1.80
82	8,180	13.63	8.82	817	600	2.67	8.36	3.45	16.38	1.80	1.42
83	3,040	6.08	1.27	606	500	2.33	6.20	3.45	12.15	1.80	1.05
84	7,260	11.19	3.45	845	650	2.75	8.64	3.45	16.92	1.80	1.47
85	5,680	10.81	—1.19	618	525	2.33	6.32	3.45	12.38	1.80	1.07

† No trunk designed.

164 Design of Intercepting Sewers.

The design of these sewers is determined by the available slope and by the points of entrance of the various trunk sewers. Sizes are based upon normal flow with sewers .8 full. To facilitate reference, the nine interceptors have each been subdivided into sections designated by letters and beginning at the upper end in each case. These sections are described as follows:

Divisions A and B.

Interceptor I.

a. From Columbia street along Post avenue, Elizabeth street, Castleton avenue, Broadway, two intervening streets and Henderson avenue to junction with Trunk 8 at Rement avenue.

b. From Rement avenue, east along Henderson avenue, along 30-foot contour and Richmond terrace to junction with Trunk 9 at Lafayette avenue.

c. From Lafayette avenue, along Richmond terrace to junction with Trunk 10 at Jersey street.

d. From Trunk 10 at Jersey street, along Richmond terrace to Church street.

e. From Church street, along Richmond terrace, Jay street, South street, Stuyvesant place, Central avenue to Arietta street.

f. From Central avenue, along Arietta street, Van Duser, Hanna street, St. Paul's avenue, Clinton, Van Duser, Wright and Boyd streets, across to junction with Trunk 13-14-15 at Canal street.

g. From Canal street, along Riker and Tompkins streets, and various other streets at about the 30-foot contour to Trunk 16 at Willow avenue.

h. From Willow avenue, south to Maple avenue; thence along Maple and New York avenues to junction with Trunk 17 at Pennsylvania avenue.

i. From junction with Trunk 17, east along Pennsylvania avenue to shore.

j. Outfall Section—From foot of Pennsylvania avenue, east to water 50 feet deep in channel.

Divisions C and D.

Interceptor II.

a. From Rockland avenue, following 50-foot contour south to junction with Trunk 20, south of Richmond Hill road.

b. Following 50-foot contour south from Trunk 20 to junction with Trunk 21, near Old Mill road.

c. From Trunk 21, following 40-foot contour eastward around spur of ridge to junction with Trunk 22-23 at Richmond Creek.

d. Richmond Creek Siphon—From junction with Trunk 22-23, east under Richmond Creek to Interceptors III. and IV.

Interceptor III.

a. From Trunk 25, following approximately the 50-foot contour to junction with Trunk 26 at Greenridge avenue.

b. From Greenridge avenue, following 50-foot contour east to junction with Trunk 27-28, near small creek.

c. Eltingville Road Siphon—From junction with Trunk 27-28, east under stream to Trunk 29-30.

165 *d.* From Trunk 29-30, following the 40-foot contour northeast to junction with Trunk 31, near fork of stream.

e. From Trunk 31, following 40-foot contour north to junction with Trunk 32, south of Clark avenue.

f. From Trunk 32, north to east end of Richmond Creek Siphon.

Interceptor IV.

a. From east end of Richmond Creek Siphon, east to junction with Trunk 33, north of Clark avenue.

b. From Trunk 33, north and east to junction with Trunk 34-35 on Amboy road.

c. From Trunk 34-35, at Amboy road, east to Tenth street, New Dorp, following Tenth street to junction with Trunk 36-37 at prolongation of Elm avenue.

d. From Trunk 36-37, north along 30-foot contour, Lincoln avenue and Thompson street to junction with Trunk 38 at Barton avenue.

e. From Trunk 38, at Barton avenue, following 30-foot contour to junction with Trunk 39 at Liberty avenue, Dongan Hills.

f. From Trunk 39, at Liberty avenue, north along 30-foot contour to junction with Sea View Avenue Force-Main.

g. From Sea View Avenue Force-Main, north along 30-foot contour to Trunk 43, south of Burgner avenue.

h. From Trunk 43, north and east along 30-foot contour to Trunk 44 on Parkinson avenue.

i. Along 20-foot contour, from Trunk 44 at Parkinson avenue to Trunk 45 at Sand Lane road.

j. From Trunk 45, on Sand Lane road, east along 20-foot contour and Old Town avenue to junction with Trunk 46 on Sea avenue.

k. From Old Town avenue, south along prolongation of Sea avenue to shore.

l. Outfall Section—From foot of Sea avenue, prolonged to shore, east 3,500 feet to water 50 feet deep in channel.

Division E. Division F.

Interceptor V.

a. From junction of Trunks 52 and 53, at Barclay avenue, following shore south and west to junction with Trunk 54, at Latourette's Pond.

b. From Latourette's Pond, following shore southwest to junction with Trunk 55, near Wolf's Pond.

c. From Wolf's Pond, southwest along shore to Seguine's Point Pumping Station.

d. From Seguine's Point Pumping Station, southeast to water 21 feet deep, 800 feet off shore.

Division G.

Interceptor VI.

a. Kreischerville Force Main—From Kreischerville Relay Pumping Station, at south end of Trunk 59, south, parallel to shore of Arthur Kill to junction with Trunk 61, at Kreischer street, Kreischerville.

b. From south end of Kreischerville Force-Main, south along shore of Arthur Kill and east along Mill Creek to junction with Trunks 62 and 63, near Richmond Valley road.

166 *c.* Mill Creek Siphon—From Junction of Trunks 62 and 63, south under Mill Creek to Mill Creek Pumping Station, on south bank of creek.

d. Mill Creek Force-Main—From Mill Creek Pumping Station, southeast to summit of ridge.

e. From Mill Creek Force-Main, at summit of ridge, southeast to Red Bank Pumping Station, at shore.

f. Gravity Outfall Section—From Red Bank Pumping Station, southeast to 21 feet of water, 1,600 feet off shore.

Division H.

Interceptor VII.

a. Richmond Creek Force-Main—From Richmond Creek Pumping Station, near Fresh Kills Bridge, west under Mill Pond outlet to junction with Trunk 71, near bend in Richmond Creek.

b. From junction with Trunk 71, at west end of Richmond Creek Force-Main, west along Richmond Creek to junction with Trunk 72-73, near fork of Fresh Kills.

c. From junction with Trunk 72-73, west to junction with Trunk 74, at a point on Fresh Kills opposite Lake's Island.

d. Fresh Kills Siphon—From junction with Trunk 74, on east bank, west under Fresh Kills to Lake's Island.

e. From west end of Fresh Kills Siphon, west to Lake's Island Purification Works, on the shore of Arthur Kill.

Interceptor VIII.

a. From junction of Trunks 75 and 76, at Springville Creek, south to Fresh Kills Pumping Station.

b. Fresh Kills Force-Main—From Fresh Kills Pumping Station, northwest under Fresh Kills Creek to Trunk 78, north of Little Fresh Kills.

c. From west end of Fresh Kills Force-Main at junction with Trunk 78, southwest to north bank of Little Fresh Kills.

d. Little Fresh Kills Siphon—From north bank, southwest under Little Fresh Kills to Lake's Island.

e. From south end of Little Fresh Kills Siphon, southwest to Lake's Island Purification Works, on shore of Arthur Kill.

f. Outfall Section from Purification Works—From Lake's Island Purification Works west to 21 feet of water in Arthur Kill, 800 feet off shore.

Division I.

Interceptor IX.

a. From junction of Trunks 82 and 83, west along Old Place Creek to junction with Trunk 84, near Old Place road.

b. From junction with Trunk 84, southwest to Bloomfield Purification Works, on shore of Arthur Kill, north of Prall's Island.

c. Outfall Section from Bloomfield Purification Works—From Bloomfield Purification Works west to 21 feet of water in Arthur Kill, 750 feet off shore.

The total length, total fall, in each section, elevation of invert at upper end, tributary area, slopes, maximum diameter, maximum discharge and discharges at .8 and .2 full for each section of these nine interceptors are summarized below:

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Tributary area, acres.	Slope 1, foot in—	Maximum diameter, feet.	Maximum discharge, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full Velocity, sec. ft.	Sewer 0.2 full Discharge, sec. ft.
A-B—											
I.											
a	5,280	4.40	29.49	4,335	1,200	4.33	44.34	3.45	44.34	1.80	3.84
b	7,390	5.68	25.09	4,938	1,300	4.67	50.51	3.45	50.51	1.80	4.39
c	2,110	1.46	19.41	5,349	1,450	4.83	54.71	3.45	54.71	1.80	4.75
d	1,450	0.97	17.95	5,626	1,500	5.00	57.55	3.45	57.55	1.80	5.00
e	5,670	3.78	16.98	5,734	1,500	5.17	58.65	3.45	58.65	1.80	5.09
f	6,000	4.40	13.20	5,829	1,500	5.17	59.62	3.45	59.62	1.80	5.18
g	4,490	2.56	8.80	7,149	1,750	5.67	73.12	3.45	73.12	1.80	6.35
h	3,170	1.76	6.24	7,602	1,800	5.83	77.75	3.45	77.75	1.80	6.74
i	920	0.48	4.48	8,013	1,900	6.00	81.95	3.45	81.95	1.80	7.12
j	Outfall section.										
C-D—											
II.											
a	4,360	7.27	41.17	1,380	600	2.50	14.12	3.45	14.12	1.80	1.23
b	3,300	5.28	33.90	1,595	625	2.67	16.32	3.45	16.32	1.80	1.42
c	5,410	7.22	28.62	2,003	750	3.00	20.49	3.45	20.49	1.80	1.78
d	Richmond Creek siphon										
III.											
a	3,160	7.04	41.59	526	450	1.67	5.38	2.88	5.38	1.50	0.47
b	4,220	7.03	34.55	683	600	2.00	6.99	2.88	6.99	1.50	0.61
c	Eltingville road siphon.										
d	2,380	1.77	27.32	2,412	1,350	3.67	24.68	2.88	24.68	1.50	2.14
e	6,200	4.14	25.55	2,817	1,500	4.00	28.82	2.88	28.82	1.50	2.50
f	1,060	0.71	21.41	2,924	1,500	4.00	29.91	2.99	29.91	1.56	2.60
168											
C-D—											
IV.											
a	1,720	1.15	20.70	6,000	1,500	5.17	61.38	3.45	61.38	1.80	5.32
b	4,620	2.98	19.55	6,180	1,550	5.25	63.22	3.45	63.23	1.80	5.49

c	4,620	2.72	16.57	6,724	1,700	5.50	68.79	3.45	68.79	1.80	5.97
d	3,700	2.06	13.85	7,513	1,800	5.83	76.87	3.45	76.87	1.80	6.66
e	2,900	1.57	11.79	7,811	1,850	5.83	77.87	3.45	77.87	1.80	6.75
f	260	0.14	10.22	7,982	1,850	6.00	78.60	3.45	78.60	1.80	6.82
g	1,060	0.51	10.08	9,504	2,100	6.50	97.24	3.45	97.24	1.80	8.45
h	4,480	2.04	9.77	9,902	2,200	6.67	101.31	3.45	101.31	1.80	8.80
i	3,960	1.80	7.53	10,203	2,200	6.75	104.39	3.45	104.39	1.80	9.05
j	2,110	0.88	5.73	10,441	2,400	6.83	106.82	3.45	106.82	1.80	9.25
k	790	0.35	4.85	10,574	2,400	6.83	108.18	3.45	108.18	1.80	9.39
E—											
F—											
V.											
a	2,240	6.40	8.14	782	350	2.00	8.00	3.45	8.00	1.80	0.69
b	5,410	9.85	1.74	1,280	550	2.50	13.09	3.45	13.09	1.80	1.13
c	1,320	1.89	—8.11	1,975	700	3.00	20.20	3.45	20.20	1.80	1.75
d	Outfall section.										
G—											
VI.											
a	Kreischerville force main.										
b	6,200	10.30	0.77	1,382	600	2.50	14.14	3.45	14.14	1.80	1.22
c	Mill Creek siphon.										
d	Mill Creek force main.										
e	3,700	24.68	28.68	2,624	150	2.50	26.84	6.68	26.84	3.48	2.34
f	Outfall section.										
H—											
VII.											
a	Richmond Creek force main.										
b	5,150	8.58	2.36	745	600	2.00	7.62	2.88	7.62	1.50	0.66
169											
c	2,640	3.11	—6.22	1,255	850	2.67	12.83	2.88	12.83	1.50	1.11
d	Fresh Kills siphon.										
e	1,580	2.26	—9.74	2,010	700	3.00	20.55	3.45	20.55	1.80	1.78

Section.	Length, feet.	Total fall, feet.	Elevation of invert, upper end.	Tributary area, acres.	Slope 1, foot in—	Maximum diameter, feet.	Maximum discharge, feet.	Sewer 0.8 full. Velocity, sec. ft.	Sewer 0.8 full. Discharge, sec. ft.	Sewer 0.2 full. Velocity, sec. ft.	Sewer 0.2 full. Discharge, sec. ft.
VIII.											
a	5,540	6.16	—3.84	1,349	900	2.75	13.80	2.88	13.80	1.50	1.20
b	Little Fresh Kills force main.										
c	1,980	2.20	—7.37	2,832	900	3.50	28.97	3.45	28.97	1.80	2.51
d	Little Fresh Kills siphon.										
e	1,720	1.91	—10.09	2,832	900	3.50	28.97	3.45	28.97	1.80	2.51
f .....Outfall section.											
IX.											
a	2,640	2.93	—4.81	1,423	900	2.75	14.56	2.88	14.56	1.50	1.26
b	5,540	4.26	—4.74	2,268	1,300	3.50	23.20	2.88	23.20	1.50	2.01
c	Outfall section.										

170 Pumping Stations and Force Mains.

These plans contemplate the establishment of eleven pumping stations, the ultimate maximum capacity and the approximate locations of which are tabulated below. The capacities given are net horse-power without reference to efficiency and refer to total lift between pump well level and elevation of upper flow-line or ordinary maximum high tide as the case may be and include estimated loss of head in force-mains.

Table of Pumping Stations.

Designation.	Serving.	Discharge, sec. ft.	Lift, feet.	Power developed, h. p.
Van Pelt avenue relay	Trunk No. 1	3.44	5.82	2.40
Sea View avenue	Sea View avenue force main	18.64	27.56	58.30
Great Kills	Outfall E	20.20	16.17	37.40
Seguine's Point	Outfall F	34.14	13.54	52.50
Red Bank	Outfall G low level lift	12.25	14.13	22.30
Mill Creek	Mill Creek force main	26.84	42.16	128.90
Kreischerville	Kreischerville force main	12.11	16.48	22.65
Lake's Island	Lakes Island purification works.	50.75	16.61	95.90
Richmond Creek	Richmond Creek force main	6.73	17.70	13.53
Fresh kills	Fresh Kills force main	19.61	6.79	15.1*
Bloomfield	Bloomfield purification works	40.13	16.06	76.00
Total power required				525.01

There will be six force-mains in the ultimate development of this plan, the essential details of which are tabulated below:

Table of Force-Mains.

Designation.	Length, feet.	Max. disch., sec. ft.	Vel., ft. per sec.	Diam., feet.	Elev. pump well.	*Lift, feet.	Power required, h. p.
Columbia St., Trunk 1-2-3	2,240	18.01	2.55	3.0	—12.00	45.87	93.85
Sea View Ave., Trunk 40-41-42	5,280	18.64	2.64	3.0	—10.00	27.56	58.30
Kreischerville, Intercept. VI. *a*	2,640	12.11	2.84	2.33	—12.00	16.48	22.65
Mill Creek, Intercept. VI. *d*	3,560	26.84	2.79	3.5	—10.00	42.16	128.90
Richmond Creek, Intercept. VII. *a*	2,100	6.73	3.09	1.67	—10.00	17.70	13.53
Fresh Kills, Intercept. VIII. *b*	3,040	19.61	2.77	3.0	—10.00	6.79	15.13

* NOTE.—The lift as given includes the loss of head in the pipe.

171 Siphons.

Five inverted siphons will be required located as follows:

Richmond Creek Siphon (Interceptor II., section *d*)—From junction Trunk 22-23, east under Richmond Creek to Interceptors III. and IV.

Eltingville Road Siphon (Interceptor III., section *c*)—From junction with Trunk 27-28, east under stream to Trunk 29-30.

Mill Creek Siphon (Interceptor VI., section *c*)—From Junction of Trunks 62 and 63, south under Mill Creek, to Mill Creek Pumping Station, on south bank of creek.

Fresh Kills Siphon (Interceptor VII., section *d*)—From junction with Trunk 74, on east bank, west under Fresh Kills to Lake's Island.

Little Fresh Kills Siphon (Interceptor VIII., section *d*)—From north bank, southwest under Little Kills to Lake's Island.

The essential details of these siphons are tabulated below:

Table of Siphons.

Designation.	Location.	Length, feet.	Diameter, feet.	Maximum discharge.	Velocity, feet per second.	Loss of head, feet.
Richmond Creek Interceptor II. (*d*).	Under Richmond Creek.	920	3.3	31 47	3.27	0.79
Eltingville road Interceptor III. (*c*).	Near Eltingville road..	300	2.0	18.00	2.55	0.20
Mill Creek Interceptor VI. (*c*)..	Under Mill Creek.....	330	2.0	21.80	2.10	0.47
Fresh Kills Interceptor VII. (*d*)..	Under Fresh Kil's.....	330	2.0	20.35	2.90	0.41
Little Fresh Kills Interceptor VIII (*d*)	Under Little Fresh Kills.....	700	3.5	27.97	3.01	0.32

Points of Discharge, Pollution of Waters, and Purification Necessary.

The seven outfall sewers have been described as the last section in each case of the seven interceptors. Their location is more definitely shown upon the accompanying map. The question of the effect of these discharges upon the surrounding waters and of the purification necessary for the prevention of nuisance, is discussed fully in our general report upon the pollution of the waters of New York Harbor and the purification of sewage entering these waters. For the reasons more fully discussed in that report, no purification is thought necessary for Outfalls A-B, C-D, E-F and G. Outfalls H and I both discharge into the Arthur Kill. Owing to the comparatively poor tidal circulation available at these points, the small volume of water in which the discharge takes place, and the relatively large amount of pollution at present existing in these waters, it is recommended that a partial purification of the sewage from both of these outfalls be undertaken. A process of short-time sedimentation and of forced aeration similar to that employed by us in our Brooklyn experiments will probably be found satisfactory and sufficient.

The further details of the design of these outfall sewers which was omitted from the table of interceptors is summarized below:

Complainants' Exhibit
No. 136.
Page 173.



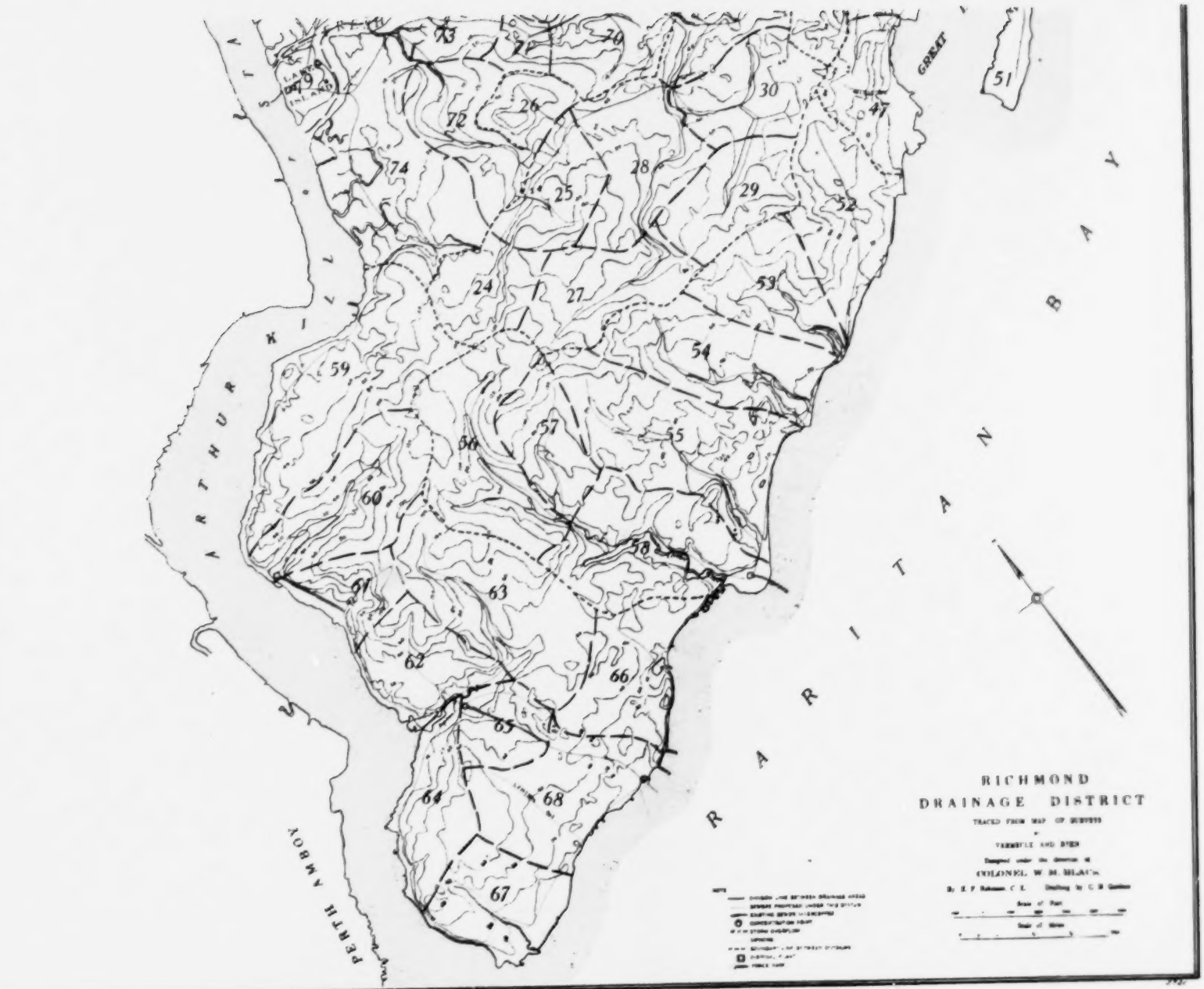

ARTHUR KILL
RARITAN BAY
PERTH AMBOY
GREAT
RICHMOND
DRAINAGE DISTRICT
COLONEL W. H. BLACK

Table of Outfalls.

Number.	Maximum discharge, sec. ft.	Discharge, gallons. per 24 hours.	Discharge by	Diameter, feet.	Length, feet.	Distance off shore, feet.	Depth discharge, feet.
A-B	81.95	40,594,824	Gravity	2-4	600	600	50
C-D	108.18	53,586,000	Gravity	3-4	3,500	3,500	50
E	20.39	10,099,300	Force main	3.0	6,200	5,000	12
F	34.14	16,910,856	Force main	4.0	1,580	800	21
G	39.09	19,362,888	Gravity	4.0	1,720	1,600	21
H	50.75	25,139,376	Gravity	4.5	1,060	800	21
I	40.13	19,878,912	Gravity	4.0	1,060	750	21

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

New York, February 15, 1911.

(Here follows map marked page 173, Complainants' Exhibit 136.)

174 *Special Report on the Oxygen Content of Sea Water as a Standard for Measuring Sewage Pollution Submitted to the Board of Estimate and Apportionment July 1, 1910.*

175 BOARD OF ESTIMATE AND APPORTIONMENT,
CITY OF NEW YORK, June 27, 1910.

Hon. William J. Gaynor, Mayor, Chairman of the Board of Estimate and Apportionment.

SIR: Colonel William M. Black, who is making an investigation of the location of sewer outlets and of the disposal of sewage for the Board of Estimate and Apportionment, and Professor Phelps, who is associated with him in this work, have handed me a report dated June 7, in which they point out the important bearing which the amount of unpolluted water daily entering the harbor of New York has upon the sewerage problem, and the lack of definite information upon this subject.

There is no question but that the starting point of any investigation designed to offer a solution of this problem must be a determination of the capacity of the harbor to take care of the sewage discharged into it without permitting the water to become so polluted as to be offensive. While some data has been collected by the United States Coast and Geodetic Survey and by the New York Bay Pollution Commission, the information is very meagre. The report of the Metropolitan Sewerage Commission has not been published, but I understand that this Commission has not secured sufficient information along these lines to lead to a definite conclusion. This would seem to be an excellent line of investigation for this Commission to follow, and I would recommend that the report of Colonel Black and Professor Phelps be sent to the Metropolitan Sewerage Commission, with the request that the Commission follow the lines of investigation suggested in the report and furnish the Board with such information as it can secure.

Respectfully, NELSON P. LEWIS,
Chief Engineer.

176 NEW YORK CITY, June 7, 1910.

Mr. Nelson P. Lewis, Chief Engineer, Board of Estimate and Apportionment, No. 277 Broadway, New York, N. Y.

DEAR SIR: The question of the proper disposal of the sewage of New York embraces many problems interesting from an engineering and an economic standpoint. For the present and probably for many years to come water carriage is and will be the most economical method of conveying sewage from the points of production to common points of disposal. To-day, the sewage is discharged at many points into the waters bordering the city. These waters form the harbor of New York and are the source of its greatness and even of its life. Their preservation in a condition fit for commerce is essential and no expenditures necessary to that end can be considered too great. The practical business sense of the American citizen only requires that he be convinced of the necessity for a given work in order to induce him to provide the means for its execution.

To-day the condition of purity of these waters is a subject of controversy. Some eminent engineers declare that their capacity for receiving and disposing of sewage is so great as to suffice not only for the needs of the population now found in the drainage area, but also for the probable increase of that population during many years. Others, professing equal technical knowledge, claim that the waters are now overtaxed and that an inadmissible and dangerous degree of pollution already exists. The former cite in support of their opinions analyses of water taken from portions of the harbor which show practically a normal degree of purity. The latter show analyses of specimens taken from other parts which show septic conditions. Both are honest in their professions, but with the system now in use by which sewage is discharged without an attempt at general distribution and without regard to the volume of flow or the circulation of the water in the vicinity of the outlets, it is natural that different localities should show to-day entirely different conditions, and that it is only necessary to make a judicious choice of locality in order to obtain an apparently irrefutable argument in support of either side of the controversy.

In so far as known, no attempt has been made as yet to consider the subject as a whole and to determine whether the capacity of the entire body of water is adequate to the task of receiving and purifying continously the sewage of the drainage area tributary to these waters.

It is evident that if the capacity be adequate, the problem resolves itself into a question of proper distribution, so that no part of this natural purification machine shall be overloaded. If it be insufficient for the work, then the load must be reduced by purifying all of the sewage partially, or by purifying a portion to a higher degree. It is quite conceivable that with improper distribution a part of the machine of limited capacity, such as Gowanus Basin, Newtown Creek or the Harlem River might be overloaded and break down, as evidenced by septic conditions, while another part does little or no work. It is further evident that with proper distribution, purification of a part to the necessary degree can be limited to and carried on at points where the physical conditions are such
177 as to permit the work to be done with the greatest economy, thus making it possible for the sewage from other localities, under conditions less advantageous for this class of work, to be discharged safely without treatment.

It is economically unwise not to take the fullest advantage consistent with safety of the great purification machine provided by nature. To do this to the best advantage, the question should be trated from the standpoint of the interests and requirements of the population of the entire drainage area, irrespective of the artificial political boundary lines. If legal conditions make this impossible for the present, then minimum subdivision should be made by the corporate limits.

In other words, if the supply of oxygen provided daily to the waters of New York Harbor is sufficient to reduce a portion of the dose of sewage daily discharged into them without causing an undue reduction of their contained oxygen (and the consequent produc-

tion of conditions of pollution), it is evident that artificial purification is required only for the remainder of the sewage, and that the purification of this excess volume can then be carried on to the extent required at those points of discharge where that work can be done most economically and advantageously to the entire community. It would then follow that, in certain districts of the city, sewage could be discharged with proper distribution into the waters without treatment, because of the treatment given elsewhere to other portions of the total daily discharge, and that the cost of the treatment wherever made should be borne by all citizens benefited, that is, by the inhabitants of all districts discharging sewage into the harbor waters. When this general treatment is made, it should not be a borough, or a ward, or a district question. Only by broad general treatment can the best and most economical results be obtained.

The ultimate disposal of sewage, the resolution into its primary elements, like that of all organic waste products, is reached by oxidation. This is true, whether the resolution take place in the air, under the earth or in the water. Water in its normal condition contains in solution a certain quantity of oxygen. About 30 per cent. of this dissolved oxygen can be removed without practical detriment to the limpidity of the water, or to its ability to support major fish life. When an unstable organic substance is discharged into water, oxidation begins at once and continues until the resolution of the substance into its elements has been made. During this process the water parts with its dissolved oxygen. If the circulation of the water be sufficient to divide the loss through a sufficient volume, no harm results, and the water gradually regains its normal oxygen contents from the atmosphere. Should the loss of oxygen be greater than 50 per cent., the water becomes offensive and major fish life disappears. Septic conditions are reached when the oxygen has been exhausted. In these conditions none but the lowest forms of life are possible and offensive gases are evolved.

As stated, the normal supply of dissolved oxygen is restored to exhausted water from the atmosphere. This process is slow in quiet waters. In streams, especially when the flow is swift, and where natural or artificial waterfalls exist, it is more rapid. For example, in 1900, the late Prof. Palmer found that the water of the Chicago Drainage Canal, above the Bear Trap Dam, at Lockport, Ill.,
178 contained 5.9 per cent. of dissolved oxygen, while 200 yards below the dam the aeration produced at the dam had increased the proportion of dissolved oxygen to 70 per cent. of saturation (Lederer, Treatment of Sewage).

In New York Harbor other sources than the reaeration from the atmosphere supply the greater part of the oxygen needed for the daily work of purification.

The sources of supply are as follows:

(*a*) The volume of normal sea water brought into the harbor daily by tidal action.

(*b*) The volume of fresh water discharged from streams emptying into the harbor.

(*c*) Rainfall reaching the harbor directly or from immediate surface drainage.

(*d*) A portion of the city water supplies.

(*e*) Reaeration by surface absorption of oxygen.

The data available from which to obtain a measure of the supply of normal sea water brought in by the tides are found in the publications of the United States Coast and Geodetic Survey relating to the circulation of the sea in New York Harbor. The investigations of the New York Bay Pollution Commission confirm and illustrate the conclusions reached by the United States Coast Survey measurements.

Gaugings of the flow through the Sandy Hook entrance, the Narrows and the North and East Rivers were made in 1886 and earlier years. From several sets of careful measurements made opposite 23d street, East River, Prof. Mitchell found that there was a preponderance of flow westward (south through the East River of about 440,000,000 cubic feet per tide. The conclusion has since been questioned, but inasmuch as the doubt was raised as a result of a theoretical discussion, without further measurement, and since other direct measurements seem to show the preponderance of flow westward, the writers accept Prof. Mitchell's conclusions. At Sandy Hook the preponderant volume of flow is to the south (outward).

To determine an approximate solution of the problem of the amount of oxygen available daily in the East River, the following method is being followed by the writers:

The calculations of the United States Coast and Geodetic Survey show for an average tide the easterly flow through the East River, opposite Old Ferry Point. When this flow begins the water level is at 4.26 feet above the mean low water plane and falling. The mean velocity is given for each lunar hour. While the easterly flow continues, the tide falls from 4.26 feet above mean low water to mean low water, and then rises to 4.47 feet above mean low water. The probable effects to the east of Old Ferry Point are that at the end of the easterly flow the entire body of water in the channel east to Stepping Stone Light, plus the tidal prism of the bays at the side, to the elevation 4.47, is composed of water, more or less polluted, which had flowed out past Old Ferry Point.

When the westerly current sets in, the tide is rising, the flow is through the channel and into the bays. As the tide rises, the tidal prism of the bays is completed from the channel and the volume of water flowing back past Old Ferry Point consists of the water
179 which had flowed out, admixed with a volume of normal sound water equal to the amount used in filling the tidal prisms of the side bays, plus the preponderance of westward over eastward flows in the East and Harlem Rivers. The volume of this normal sound water thus entering (about 1,000,000,000 cubic feet) gives the measure of the new supply of oxygen provided by one tide, and of this supply 30 per cent. can be used with safety in sewage purification. Before the tide turns again this water has been divided between the East and Harlem Rivers and has entered into its work in the harbor.

For the Sandy Hook entrance the problem is more complex. Since the preponderance of flow is southerly (outward), and since at any one flood tide the fresh sea water is carried but a limited distance into the upper bay, it would seem that, excepting in the lower bay, but a very limited admixture took place. Due, however, to a marked underrun of the northerly flow under the ebb current at the beginning of the flood and for some time before the change in current direction has occurred at the surface, the normal sea water is carried into and distributed through the upper bay and lower Hudson.

For the determination of the volumes of flow the only data available is that supplied by the United States Coast and Geodetic Survey and that obtained from the Engineer Department of the Army. In 1886 and prior years, the Coast Survey made a number of careful measurements of the flow at various sections in the Sandy Hook channels, in the Narrows, the Hudson and the East Rivers. The results were calculated and reported on by the late Prof. Henry Mitchell, whose wide experience made him a most competent investigator. The investigations were confessedly incomplete, for the problem is very complicated and difficult. A lack of funds has prevented their continuation. Other calculations based on the observations then made and on a theoretical discussion have since been made by Dr. Harris of the Coast and Geodetic Survey. Dr. Harris' conclusions as to the relative volumes of flow north and south through the East River differ from those of Prof. Mitchell, in that Dr. Harris believes that the preponderance of southerly flow is much less than that found by Prof. Mitchell. Dr. Harris' discussion assumes that the velocities of the tidal currents follow strictly the laws of variation through a section as do river current velocities. This assumption is not believed to be fully supported by the scanty records of observations available—and the writers believe that Prof. Mitchell's conclusions are probably more nearly correct. The records of surface velocities published in the Atlantic Coast tide tables, as well as the float observations made by the New York Bay Pollution Commission, in so far as reported, would seem to support this opinion. The question is so important to New York City that it is hoped that provision will be made for further study.

The investigations of the Engineer Department give the only data for the tidal conditions in the Harlem River. From them it would appear that there is a resultant flow in the Harlem toward the Hudson. The Department is now making a further study of the question in connection with work contemplated for Hell Gate and its neighboring channels, Little Hell Gate and the Bronx Kills, and more data will soon be available. New sets of observations and measurements are needed near Old Ferry Point, at the extremities of the Harlem River, in the East River, south of Hell Gate,
180 near the Battery, and in Buttermilk Channel, at the Narrows and in the Sandy Hook Bar channels—sufficient to determine with greater accuracy the daily supply to and distribution in the harbor of the normal sea water.

The volume of fresh water discharge of the streams into the har-

bor is known approximately. Since the greater part of these streams must care for the sewage from a population along their basins, little or no help for the harbor can be expected from them. Care must be taken that they be not polluted to such a degree as to add to the work which the harbor waters properly may be expected to perform. To-day the Passaic flow is probably distinctly detrimental. If care be not taken that of the Hudson may soon be in the same condition. Newtown Creek and Gowanus Basin are notoriously septic and add to the harbor's burdens. Recent analyses of the Harlem waters show conditions at times nearly as bad. It is safe to say that the Passaic, Newtown Creek, Gowanus Basin and the Harlem are overloaded.

The oxygen supply from the rainfall can be calculated approximately. In a very large part of the drainage area the run off is collected in the sewers and this, with the excess of the drinking water supply, is available for useful work, excepting when the detention in the sewers is long enough to produce septic conditions and a waste of oxygen before discharge. These conditions undoubtedly exist in many of the older and badly designed sewers. In the City of Washington, for example, the character of the sewage effluent, collected at the disposal pumping station, is to-day remarkably fresh, due to the fact that in recent years, the older sewers of that city have been reconstructed and no long detention of sewage in them now exists. The contrast between the character of the Washington sewage and that of Boston, for example, is marked. In New York, the length of the sewers is generally short, and there is little or no reason why the time elapsing between collection and discharge should not be short. If it were, the work of the harbor waters would be diminished.

For convenience, what may be termed normal American sewage is assumed to be of a dilution equal to a consumption of 100 gallons of water per day per inhabitant. The absolute composition of sewage must vary for each locality and with the changing seasons, depending on the conditions of living, the proportion of manufacturing establishments per inhabitant, and other causes. But in the larger cities there is a degree of similarity in composition and, therefore, that what is termed normal American sewage, as described by Profs. Winslow and Phelps, can be taken as representative, for calculation, in the absence of exact information. It is evident that when water consumption is at the rate of more than 100 gallons per day per inhabitant, and when the rainfall is collected in the sewers the dilution is greater, and by that dilution is supplied oxygen which is available for sewage resolution. In New York to-day data is lacking. There is no record attainable of water consumption by districts; no record of the volume of sewer discharge, either per sewer outlet or per drainage area; no record of average sewage composition and little from which the population per drainage area can be computed. Such data is required for a satisfactory discussion of the problem of sewage disposal.

181 The determination of the supply of dissolved oxygen obtained by reaeration from the atmosphere is too difficult to admit of more than an approximation. Dr. W. E. Adeney, of Eng-

land, has propounded a certain hypothesis of the rate of reaeration of harbor waters, based on a series of laboratory experiments. His work is valuable in starting investigations into this subject, but his conclusions seem erroneous.

We are now engaged in further experimentation and investigation on the same subject. At best, however, little more can be learned than the probable rate of surface absorption of oxygen by still water and its rate of diffusion to the depths below. The important effects of wind and of surface agitation by passing shipping can only be guessed. Fortunately, these effects are beneficial, and if not overestimated may be considered a valuable factor of safety. Direct observations in the harbor itself would be of much value.

It is universally admitted that the harbor must not be permitted to reach a condition of pollution which will be detrimental to human health, or which will deter shipping from using the port. The exact degree of purity to be required has never been agreed on, nor is there any uniformity of opinion to-day as to what is the general condition of the harbor as regards allowable pollution. Localities are admittedly bad and costly provisions are being taken toward improving the local conditions in at least one of these, Gowanus Basin.

It is the belief of the writers that the waters of the harbor should be maintained in such a condition as to support major fish life everywhere, and that this condition requires that in no part shall there be found less than probably about 70 per cent. of the saturation quantity of dissolved oxygen.

When the importance of the subject and the vast amount of capital involved in the proper solution of the question are considered, it would appear self-evident that ordinary business sense would require the same careful investigation into existing conditions, into the necessity for a change, and into the most economical method of attaining the desired results, as is made for proposed betterments in private business undertakings.

The writers are endeavoring to find partial solutions to the problems with the limited resources available to them. They send you this letter in the hope that further interest may be awakened in this important subject and that a presentation of the problem as it appears to them, of the methods of solution suggested, and of the difficulties encountered may lead to a further discussion and to such official action as may permit a full and careful investigation to be made and a more accurate determination of the facts to be attained.

Very respectfully,

W. M. BLACK.
EARLE B. PHELPS.

I hereby certify that the foregoing are true copies of reports presented to the Board of Estimate and Apportionment at its meetings on April 22, 1910, June 17, 1910, July 1, 1910, January 12, 1911, March 9, 1911 and March 23, 1911, and printed in the minutes (Public Improvement matters) of the meetings of the Board held on said dates.

W. H. LANG,
Secretary Board of Estimate and Apportionment.

June 20/12.

1 COMPLAINANTS' EXHIBIT No. 137.

James D. Maher, Commissioner.

4080.

Report on Sewage Disposal of Orange, Montclair, and East Orange.

James H. Fuertes, Consulting Engineer, New York.

October 14, 1911.

2 *Report on Sewage Disposal of Orange, Montclair, and East Orange.*

James H. Fuertes, Consulting Engineer, New York.

October 14, 1911.

3 NEW YORK, October 14th, 1911.

To the Joint Committee on Sewage Disposal of Orange, Montclair, and East Orange.

GENTLEMEN: Pursuant to your request I submit herewith a report on the disposal of the sewage of Orange, Montclair and East Orange, with recommendation as to the most suitable, efficient and economical plan to be adopted, together with estimates of cost of constructing the necessary works and keeping them in efficient and satisfactory operation.

Briefly, my recommendations are as follows:

1. That Orange, Montclair and East Orange unite in the construction and maintenance of a sewage purification plant at the site located partly in Bloomfield and partly in Belleville.

2. That the plant consists of grit chambers, Imhoff tanks, sprinkling filters, secondary Imhoff tanks and a sterilizing plant, costing, for construction, about $1,125,000.00, and for operation, excluding interest and sinking fund charges, about $22,500.00, and including these items about $95,000.00 per year.

3. That an arrangement be made by the three cities to perfect a joint administrative commission which shall have charge of the construction and operation of the works, and shall also have jurisdiction over the maintenance, cleaning and operation of the sewers of the three towns, including the main sewer leading to the disposal works.

Further, it is my judgment that there will be no difficulty
4 in building and operating the plant recommended in such a manner that it will not produce disagreeable odors at the plant, or in its vicinity, or along the Yantecaw River Valley; or cause the Yantecaw River to be less desirable, at any time, for any

use to which it can now be put; or in any measureable degree increase the height of floods in the river.

The data upon which these recommendations are based will be found in the following pages.

General Description of the Territory under Consideration.

Orange, Montclair and East Orange lie on elevated ground from two to four miles west of the Passaic River, and to the north and west of Newark. Orange lies to the south of, and adjoins, Montclair, and East Orange to the east of and adjoining Orange.

Montclair has the largest area, about 6.1 square miles, but the smallest population of the three. The lowest ground in Montclair is near Bellevue Avenue, and is about 170 feet above sea level, in the branch of the Yantecaw River. The highest ground is on the mountain top, to the west, which is nearly 700 feet above sea level. Practically all the built up portion of the town lies lower than 400 feet above sea level, and the larger part between 250 and 300 feet. All the sewage from the town can be collected in sewers discharging by gravity to one suitably located point for treatment.

East Orange has an area of 3.91 square miles. The lowest land, which is near Grove Street at the northern end of the town, lies about 110 feet above sea level, and the highest, which is on Prospect Street between Park and Springdale Avenues lies about 190 feet above sea level. The sewage from East Orange can all be collected and delivered by gravity to a point near Second River convenient for connection with a trunk sewer laid to take the sewage from Orange and Montclair.

Orange lies to the west of and higher than East Orange, and its sewage is now brought down to Second River and discharged through the Union outfall sewers into the Passaic River.

The above brief description of the sewerage possibilities of these three communities is given to form a basis of the investigations for a joint disposal proposition. If any significant portion of the sewage of either of the three could not be delivered to a common point of outfall, for collection and subsequent conveyance to the disposal works, without pumping then the advantages of joint action would be less desirable. As it is, the sewage of all can be taken down the valleys of either the Second or Yantecaw Rivers without excessiveiy heavy expense for the construction of the necessary sewers.

In the project which is recommended for adoption it is proposed to construct a new sewer, paralleling the present Union outfall sewer, (which serves Orange, Montclair and Bloomfield), from the junction of the sewer from Montclair to the site of the proposed disposal works in Belleville. This new sewer would be laid on a flatter, but self-cleansing gradient than the existing sewer, in order to deliver the sewage to the works at a high enough elevation to properly carry out the required processes. No pumping would be required to deliver the sewage from the three cities to the disposal works. The cost of the new sewer is included in the estimate of the cost of constructing the disposal works. The cost of the sewer from East Orange to con-

nect with the main outfall sewer is not included, as sufficient data were not at hand, on which to base an estimate.

6 Existing Sewerage Works and Character of the Sewage.

The sewers of Orange, Montclair and East Orange are all on the separate system, that is, they receive only sewage to the exclusion of rain water. A considerable amount of ground water, however, works into the sewers, and this will have to be taken care of at the disposal works.

The sewers of all the cities in this district have good slopes so that velocity of flow is great enough to keep them free from deposits.

The most distant buildings from which sewage will be conveyed to the point where the sewers from Orange and Montclair join is not more than four miles away from the junction, and with the velocities of flow that prevail sewage will reach this point in less than two hours after entering the sewers at the house connections. The sewage, therefore, will be fresh, not having had time in transit for the organic matter in it to begin to putrefy. So far as I have been able to find out, no offensive trades wastes enter the sewers in significant amounts.

To ascertain the actual condition of the sewage I have had samples collected for examination at a manhole on the joint sewer just above the tidal tank and these, together with the absence of odor at this point, where the sewage is violently agitated by falling into the manhole, confirm the conclusion that the sewage to be treated will not be in a putrescent condition when it reaches the plant. This will greatly simplify the problem of its purification.

At the present time the sewage of Orange, Montclair and Bloomfield is disposed of through the Union Outlet sewer extending down the valley of Second River, to the Passaic River. The Branch sewers

7 from Orange, and from Montclair and Bloomfield, (which use the same sewer) are each 24 inches in diameter. Below the junction of these the sewer is egg-shaped, 2 feet, 4 inches wide and 3 feet, 10 inches high, there being, however, some 36-inch and some 30-inch stretches, including river crossings. From the tank to the outlet into the Passaic, a distance of some 3,800 feet, it is of cast iron 48 inches in diameter.

Quantity of Sewage to be Provided for.

Based upon the available data, the sewage originating in the three cities, which are of the same nature as to occupancy and commercial interests, should average about 100 gallons per capita.

The sewage does not flow through the sewers at a uniform rate throughout the twenty-four hours, or at the same rate on different days; from general experience it is found that the least flow is about 2 or 3 o'clock in the morning, increasing to a maximum about 9 to 10 o'clock in the morning, then decreasing towards noon and rising again about 2 in the afternoon, and that the maximum rate of flow to be expected will be from one and a half to two times the average rate of flow. Since there will be no storm water to be taken care of

in the system the works can be designed to accommodate the quantities of sewage that will result from the populations given in Table I, with an additional allowance to provide for the ground water entering the sewers.

Daily gaugings of the depth of flow in the sewers from Orange, and from Montclair and Bloomfield, have been kept since 1894, for the purpose of apportioning the cost of maintenance of these sewers among the cities using them, payment being made on the basis of relative use. A study of these gaugings which were placed at my disposal by Mr. Crane, City Engineer, of Orange, N. J., shows that a very considerable percentage of the total flow is ground water which leaks into the sewers. An analysis of these records indicates
8 that the ground water flow varies from season to season through a wide range. For instance, during the first 7 months of the year 1908 both sewers ran entirely full, for the entire period, and at times were much over-taxed. During the past 8 months of 1911, however, they have run about 2/3 full most of the time, and entirely full for about a month. As nearly as I can estimate the minimum ground water flows in these two sewers together has been about 4,000,000 gallons per day and the maximum in excess of 7,000,000 gallons, or, reduced to leakage per square mile of sewered area, the figures would be about 280,000 gallons for the smallest rate and over 490,000 gallons per square mile per day for the greatest. Adjusting these figures to the cities of Orange, Montclair and East Orange the quantities of ground water to be taken care of at the disposal works would be about 3,500,000 gallons daily for the ordinary dry weather flow, and 6,000,000 gallons daily for wet weather flow, the latter rate persisting for possibly half a year at a time. For shorter times rates reaching nearly 9,000,000 gallons daily are likely to be reached.

The past, present and estimated future populations of Orange, Montclair and East Orange are given in Table I.

TABLE I.

Populations.

City.	Areas. Sq. miles.	Populations. 1900. U. S. Census.	1910. U. S. Census.	Estimated For 1925.	Estimated For 1940.
Orange	2.22	24,141	29,630	45,000	60,000
Montclair	6.10	13,962	21,550	35,000	50,000
East Orange.....	3.91	21,506	34,371	53,000	70,980
Totals.....	12.23	59,609	85,551	133,000	180,380

Disposal works should be built of sufficient capacity to pro-
9 vide for some years in advance of the present, so as not to require extension immediately. On the other hand, it would not be economical, either as to cost of construction or efficient operation to build them large enough to serve populations that will not

be reached for more than a generation. In my judgment works large enough to take care of the population that may be expected by 1925 will be as large as should be built at present, as this will give sufficient margin of capacity to permit extensions to be made, should the population increase more rapidly than estimated above, in ample time to provide for the increased population. On the other hand, the main sewer leading to the works, which would be costly to duplicate, should be large enough to take care of the maximum rate of flow to be expected by 1940.

Based on the populations given in Table I., and on the assumption that, on account of the considerable time that some of the sewage will require to reach the disposal works, the maximum rate of sewage flow will be 50 per cent. in excess of the average rate, the maximum quantities of sewage that would reach the disposal works, in 1940, from the three cities, including ground water, would be as given in Table II.

TABLE II.

Estimated Maximum Rate at which Sewage Will Reach the Disposal Works in 1940.

Million Gallons Daily.

City.	Constituent parts of sewage. House sewage (150 gallons per capita).	Ground water 700,000 gallons per sq. mile daily.	Trade wastes.	Total maximum rate of sewage flow.
Orange	9.00	1.82	0.85	11.67
Montclair	7.50	4.31	0.01	11.81
East Orange	10.65	2.74	0.09	13.48
Totals	27.15	8.87	.95	36.96

10 For the average conditions of flow that may be expected in 1925, the figures would be given in Table III.

TABLE III.

Estimated Average Rate at which Sewage Will Reach the Disposal Works in 1925.

Million Gallons Daily.

City.	Constituent parts of sewage. House sewage (100 gallons per capita).	Ground water 280,000 gallons per square mile.	Trade wastes.	Total.
Orange	4.50	.62	.26	5.38
Montclair	3.50	1.70	.01	5.21
East Orange	5.30	1.09	.03	6.42
Totals	13.30	3.41	.30	17.01

On the above assumptions, therefore, the capacities of the principal divisions of the works should be able to accommodate the quantities of sewage estimated as follows:

The main outfall sewer to the disposal plant, and the main outlet pipe from the works, the maximum rate of sewage flow from 181,000 people, amounting, including ground water flow, to 37,000,000 gallons per day, the sewer to run three-fourths full with this quantity of sewage.

The disposal works, the average rate of sewage flow from 133,000 people, amounting, including ground water, to 17,000,000 gallons per day, the works being so laid out as to permit of extensions, when necessary, to provide for receiving the sewage from a population of 181,000 people, amounting, including ground water, to an average rate of flow of 23,000,000 gallons daily.

Although the average rate of flow of the sewage in 1925
11 will be about 17,000,000 gallons daily there will be times when the rate will reach about 23,000,000 gallons and the works will have to take care of it as it comes. By proportioning the plant properly the increased rate necessary for a few hours daily will not injuriously affect the character of the effluent, as the processes to be used are flexible enough to secure satisfactory results within these limits.

Methods of Disposal of Sewage.

Sewage from cities like Orange, Montclair and East Orange, consists of water carrying away, partly in suspension and partly in solution, the wastes from the houses and buildings of the people. About 999 parts out of a thousand, by weight, of the sewage, are clean water, and it is the organic portion of the one part, (which latter is about half mineral and half organic matter) which, by decomposition and putrefaction gives rise to foul odors and nuisances. The construction of purification works, of considerable cost, therefore, is made necessary by a relatively small amount of putrescible organic matter in a very large amount of water, and the problem is one of removing this small amount of organic matter from the water, or destroying it, or changing it before putrefaction sets in to a form in which it will not subsequently become offensive.

Generally speaking the process, for economical and practical reasons, must be done in two stages, the first being to remove quickly, before decomposition sets in, by subsidence, screening, filtering, or combinations of these, as large a part of the suspended matters from the sewage as advisable under the condition prevailing. These suspended matters consist of silt, sand, coagulated clay, fibres and pieces of paper, rags wood and resistant solids, particles of excrement, scraps of meat, vegetables and other refuse from houses, markets, and factories.

12 The second stage in the treatment is to oxidize or destroy those portions of the wastes in solution, and of the solids in suspension, particularly those of an organic origin, too small to be removed by the processes available for the first stage of the treatment, and to destroy and eliminate the bacteria which accompany the

organic matter in the sewage and which pass through the first stage of treatment without being reduced materially in numbers.

The first stage of the treatment is essentially mechanical, as the work must be done quickly in order to keep the sewage fresh and inodorous when it undergoes the second stage of treatment, which is essentially chemical, although the resulting chemical changes are largely brought about by living organisms.

For the first stage two operations are necessary, the first being to separate the suspended matters from the liquid sewage and the second to dispose of these suspended particles after they have been removed. The first stage is necessary for the reason that if not carried out the second stage would fail by the clogging of the works, with resultant putrefaction and nuisances which might necessitate the reconstruction of the works. When the first stage is efficient the second is easy of consummation; and the more efficient the first the greater the success and efficiency of the second.

The extent to which the purification of the sewage must be carried in any case depends upon local conditions. When an outlet can be had to the open sea, or to a great river whose flow is large enough to disperse, dilute, and purify it, no treatment is necessary save perhaps screening and the removal of sand. Where the outlet is into a small stream running through pasture lands, or serving as a water supply or ice supply for inhabitants in the vicinity, the sewage must be purified to as high a degree, and to as uniform a quality, as possible of attainment.

13 The processes available for the first stage, stated in the order of their efficiency in the removal of suspended matters from the sewage are: coarse screens; fine screens; ordinary settling basins, operated with or without chemicals; slate beds; specialy designed settling basins (such as the Dortmund and Imhoff tanks); and especially designed, rapidly operated filters in connection with special forms of settling basins.

Coarse screens will remove only large particles and floating matters. Fine screens will remove a somewhat larger percentage of such matters, but fail to intercept the finest particles of silt and mud in suspension. The particles removed by screens are disposed of by burning or burying.

Ordinary settling basins, when well designed, will largely remove the suspended matters, which require frequent removal to avoid nuisances. The sludge resulting from deposition in such basins is great in amount and difficult to dispose of owing to its large percentage of water and the slowness with which it dries out. Its disposition is effected, when no chemicals are used, by draining it off into lagoons to dry out, and then digging it out and hauling it away; or plowing it into the ground where this is feasible, or discharging it into tanks, or trenches, to "work" or digest, and after reaching a proper condition, digging it out and hauling it away; or, where chemicals are used, passing it through so-called filter presses to squeeze out the water, using the resulting cakes of pressed sludge for filling low ground, or otherwise disposing of it.

Mr. J. W. Dibden, of London, has in recent years introduced in

many places special settling basins containing layers of slate arranged to facilitate the deposition of the solids and their digestion in an inodorous manner. The efficiency of such beds, so far as the effluent sewage is concerned, is about the same as of septic
14 tanks, and its disposal involves about the same problems. The humus, or sludge, however, from such beds, when these are properly designed and operated, is inodorous and smaller in quantity than from ordinary settling basins. The cost of the beds for many locations, however, would be great in comparison with other processes producing under ordinary conditions equally good or better effluents.

Specially designed settling basins, such as the Imhoff tank, so-called in honor of Dr. Karl Imhoff, of Essen, who perfected it, will remove as large a percentage of the suspended matters from the sewage as can be economically taken out by subsidence, and at the same time reduce these deposited matters to an inoffensive condition of smaller volume than deposits from similar sewage in ordinary settling basins; further, the condition of the sewage itself as to freshness is not altered while passing through the tanks.

Specially designed rapidly operated filters, in connection with specially designed settling basins, will remove practically all of the suspended matters, and when operated in connection with chemicals, a portion of the dissolved organic and mineral matters, and give a clear effluent, and one that could be discharged into relatively smaller streams, without fear of nuisance, than the other preliminary processes. The matters removed from the sewage by the filters would be passed back to the settling tanks to be digested with the matters deposited from the sewage therein before reaching the filters.

The removal of the deposits from the specially designed settling basins, in these two last mentioned processes, would be accomplished by emptying it from the bottoms of the tanks upon shallow beds of fine gravel where the water would drain out and permit the sludge to dry out. The dried sludge would be removed and disposed of on low ground in the vicinity, or wherever convenient. Sludge removed from such tanks dries readily. Its water content is much less
15 than that of sludge removed from ordinary settling basins, and when discharged upon beds for drying is charged with inodorous gases, evolved during its digestion in the tanks, which makes it light and porous, permitting the water to drain out readily.

Other preliminary processes for the removal of the suspended matters, being modifications and combination of the above, are in use at various places at home and abroad, but the methods outlined elucidate in a broad way the principles underlying all the methods in practical operation.

Among the modifications may be mentioned one wherein the sewage is retained in the settling basins for a long enough time to allow putrefaction to begin, with the aim of thereby reducing the quantity of sludge to be handled, by causing some of the solids to go into solution and be carried out of the tank with the sewage. Tanks of this sort are called septic tanks and a few years ago were introduced extensively. Owing to the difficulty of disposing of the effluent from the tanks, which generally smells badly, their use is now limited

to special situations and conditions. Another modification is the use of coarse grained filters, operated at a rather high rate, to serve the purpose of very fine screens. Such filters, however, are usually short lived, unless elaborate provisions are made for keeping them cleaned, otherwise when they become clogged the filtering materials require removal and replacement.

It will be seen, therefore, that a decision as to the proper method of preparatory treatment to be adopted will depend upon the method of secondary treatment necessary, and this must be adjusted to give the character of effluent desired from the plant.

The more prominent and widely used forms of secondary treatment are:

16 1. The treatment of the sewage with chemicals which assist in producing a relatively rapid and extensive deposition of the solids in suspension, and the removal of about half of the organic matters in solution.

2. The disposal of the sewage by using it to irrigate large tracts of land, either for raising crops of various sorts, or for getting rid of it. This process requires a large area of land, and has the disadvantage that during rainy weather, when the ground is soaked with water, the sewage can not be taken care of so readily, and ponding is apt to result.

3. Passing the sewage through contact beds. These are tanks containing relatively coarse granular materials, through which the sewage is passed in a manner to bring it in contact with the air entrained in the bed and allowing it to stand for a certain length of time to produce the necessary oxidation and bacterial action; the sewage is then emptied out, either to a second set of similar beds or to its final place of discharge, depending on the degree of purification desired. Such beds, when properly designed and operated, are inodorous, produce excellent results, giving an effluent acceptably clear and oxidized to a condition of stability, that is: rendered non-putrefactive. Generally, however, such beds eventually partially clog up with the sewage matters deposited therein and the filtering matters have to be removed and new ones put in their place. The relative permanency of such beds depends upon the fineness of the materials and the extent to which the preliminary process used removes the suspended matters.

4. Spraying the sewage over deep beds of coarse granular materials. Such beds are called sprinkling filters. Sprinkling filters, when properly designed and operated, will oxidize the organic
17 matters in solution in the sewage, as well as the fine particles in suspension to a stable or non-putrescible condition. The effluent from such filters, however, is not clear, as the clay, silt, etc., is not retained by the coarse-grained materials forming the bed. Their life depends upon their ability to unload or discharge the matters temporarily retained therein after their conversion to a non-putrescible condition. Generally, therefore, further treatment is necessary to remove the suspended matters from the effluent, and this may be done by subsidence, by passing it through contact beds, or by filtration through specially designed filters, the water used in

washing which would be discharged back into the raw sewage entering the preliminary treatment works. Contact beds for this purpose offer the disadvantage of gradual loss of capacity by clogging, and of changing unfavorably the chemical character of the effluent from the sprinkling filters, when this has to be discharged into streams and ponds.

5. Filtration of the sewage through specially prepared beds of sand by applying it to the filters intermittently in doses no larger than the character of the sewage and construction of the beds will permit to secure the oxidation of the organic matter and removal of the bacteria. When properly designed and built such filters will purify the sewage to a very high degree, yielding an effluent clear, non-putrescible and freed from a very large percentage of the bacteria. The necessary works, however, are generally expensive to build, particularly when the beds have to be artificially constructed of sand brought from a distance; further, they must be operated with intelligence to keep them in an active and efficient condition.

18 In some cases it is necessary to carry the purification to still greater lengths than can practically be obtained by any of the above mentioned processes, and in such cases the effluent from the works can be sterilized, after being rendered clear and non-putrescent, by the use of some sterilizing agent, such as hypochlorite of lime or soda, or by the use of ozone, which can be prepared from the air by electrical treatment.

Available Sites for Disposal Works.

The method of disposal that will be best suited to local conditions will depend upon the sites available for the works.

After looking over the situation with much care I have found but two localities where works could be located. These are:

1. The site selected and now controlled by the cities interested, which is located in the northwest corner of the Town of Belleville, and northeast corner of Bloomfield.

2. One of two sites on the meadows of the Hackensack River.

The second mentioned sites, while suitable for the construction of the works, are far away and lie beyond the hill which separates the Passaic River Valley from the Hackensack Meadows and to utilize one of these would necessitate building and maintaining a pumping station to elevate the sewage over the hill; and to utilize the other, resorting to pumping, or to the use of an inverted siphon to get the sewage over the 60-foot hill east of the Passaic River, in addition to constructing several miles of large trunk sewer, for either site. The cost of pumping the sewage, without interest, depreciation and sinking fund charges on the cost of the sewer and pumping station, would, for the lower site, be upwards of $40,000.00

19 per year, which would represent, at 5% interest, a capital investment of $800,000.00, and would make the project less desirable from a financial standpoint than the Belleville site, as practically the same character of effluent would be required from the works in either case in order to avoid, in the case of the meadow site, the pollution of the Hackensack River and Newark Bay. The use

of the upper meadow site, with an inverted siphon under the Passaic, while possibly practicable, would involve much expense for construction, and some difficulties in operation, which can be avoided at the Belleville site.

This being the case the problem in hand becomes one of determining the character of effluent required from works situated at the Belleville site, and the conditions that must be fulfilled with respect to the avoidance of nuisances locally.

Character of Effluent Required.

The tract of land chosen for the location of the disposal works lies along the south bank of the Yanteeaw, or Third River, the effluent from the proposed plant must be discharged into this stream. In order to design the works, therefore, it will be necessary to know the conditions of flow that prevail in the stream at different seasons, the topographical, meteorological and geological features of the district, the character of the country through which the stream flows as to occupation for residences and manufactories and the probabilities for future growth and improvement for these uses that would be affected by the construction of the works.

Immediately below the proposed site is a shallow pond some 2,000 feet long formed by a dam about 2,300 feet up stream from Harrison Street. A little over a mile further down is another dam, the back water extending up to within about a mile of the first mentioned pond. Three-fourths of a mile below the second dam is a third forming a pond about 2,000 feet long, furnishing power to a paper mill, and three-fourths of a mile below this is a fourth, which supplies two mills, the larger of which is a bleaching mill. The back water from this pond reached up to within half a mile of the third dam. There are no other dams on the stream before its junction with the Passaic opposite Lundhurst. Between the ponds formed by these dams the stream is in some places swift and others sluggish, winding about the valley through a shallow channel with low banks bordered by grass lands, lawns and fields, and some marsh lands. Generally speaking the banks are covered with underbrush and the channel more or less obstructed with growths of various sorts although some portions have been straightened and cleaned out.

For about half a mile below the proposed works to below Nutley, and Franklin, the stream flows through a well built up suburban residential district containing many fine properties, to some of which the creek in a clean wholesome condition is a valuable asset while in an unclean condition would be not only a nuisance but a damage of serious proportions. The water of the creek is not, and should not be used for a domestic water supply, whether the proposed sewerage works are built or not, and should not, whether it is now so used or not, be taken as an ice supply for the people of the vicinity, so that for these purposes the effluent from the proposed works, if of a high enough purity, would not damage the stream.

There are clear indications that in the future the district through which the stream runs will continue to improve, and that the popu-

lation resident in the valley and surrounding hills will increase, probably more rapidly than it has in the past.

21 A comparison of the sewage flow from 181,000 people (the estimated population 1940) to the estimated natural flow of the stream, which has a watershed area of about 8.6 square miles above the site of the proposed works, is given in Table IV.

TABLE IV.

	Estimated flow of Yantecaw River, in million gallons daily.	Average rate of sewage flow in 1940, in million gallons daily.
Minimum daily flow of river	0.7	23
Minimum monthly flow of river	1.0	23
Flows for average year:		
Driest month	3.8	23
2nd driest month	4.0	23
3rd " "	4.2	23
4th " "	4.7	23
5th " "	6.6	23
6th " "	8.0	23
7th " "	9.5	23
8th " "	11.7	23
9th " "	13.6	23
10th " "	13.9	23
11th " "	14.2	23
Wettest month	14.3	23
Frequent flood flow	200.0	23
Large flood flow	430.0	23
Maximum flood flow	1200.0	23

It is evident, from this Table, that the character of the effluent from the plant must be of a high order, as the sewage flow, even when the plant is first put in operation, will average greater in amount than the average natural stream flow throughout practically the entire year.

During ordinary floods, which occur with frequency, the sewage flow will not have any noticeable effect towards raising the flood heights, and this effect will diminish with the intensity of the floods.

If the sewage is purified to a high enough degree, however, the effect of its discharge into the stream will be beneficial by causing a more copious and uniform flow throughout the year. All the sewage reaching the works, therefore, would have to be purified to a very high degree.

22 The water of the Yantecaw River is now somewhat discolored and polluted by manufacturing wastes, but is not very offensive, as no great quantity of sewage enters it.

Its velocity, however, is rather sluggish throughout most of its length, owing to the presence of the dams above mentioned, which

have been in existence for many years for furnishing power and for other uses.

Summing up, it can be seen that to fulfill the necessary conditions the effluent from the proposed works must be free from suspended matters, clear, free from odors, free from matters in solution that would putrify and cause disagreeable odors, and free from constituents that would cause troublesome growths in the stream and ponds, especially during times when the water would naturally be clear. It is also necessary that the removal of the bacteria from the effluent should be great enough not to cause added pollution to the stream, particularly with respect to those forms which contribute to, or cause, water borne diseases. In other words, the effluent from the plant should always be in as good or better condition than the natural flow of the stream.

Other conditions, however, must also be fulfilled by the works and these relate mainly to the simplicity of the plant, its reliability and its flexibility in dealing with varying quantities of sewage flow without diminution of efficiency, and without causing offensive odors or other nuisances at the works, or in the stream below the works.

Type of Plant Best Suited to the Site Selected.

From surveys which have been made by Mr. Crane, City Engineer, of Orange, N. J., it appears that the invert of the main sewer can be placed at an elevation of 89.5 feet above sea level at the disposal works. The elevation of the surface of the sewage in the
23 sewer, at the works, at minimum flow, will be, therefore, 91.5 feet above sea level. As the water in the Yantecaw River at ordinary stages is 72 feet, the available head for passing the sewage through the plant will be 19.5 feet, which is sufficient for the purpose.

In the matter of purification it is best to consider first the most suitable method of final disposal and then select the method of preparatory treatment that will be best adapted to prepare the sewage for final treatment.

Broad irrigation is out of the question as there is not enough land available for the purpose. It would probably require about 2½ square miles of land, with soil of the kind common in that locality, to properly assimilate the sewage, and the cost of maintenance would be greater than any possible revenues that could be had from crops that could be successfully grown on the area.

Chemical precipitation would be unsuitable, unless followed by, or combined with other processes, as the effluent, although clear, would still contain enough organic matter to putrefy and cause a nuisance.

Contact beds, particularly if used in series so that the effluent from one set of beds would pass through a second set before discharged into the stream, where the method can be used, will give a stable effluent of good purity and the works can be maintained without nuisance. In order to use this method successfully the sewage must be delivered to the works at a high enough elevation to permit of the construction of the works, using a sufficient depth of filtering

materials to effect the proper purification, and allowing sufficient extra head to operate the mechanisms necessary to discharge the sewage into each set of beds and permit them to drain out again before the next filling. A further requirement is that provisions must be made in the maintenance charges for renewing the filtering materials at greater or lesser intervals of time, owing to the retention therein of the accumulating, unchangeable mineral matters. Double contact beds could not be built at the available site without pumping all the sewage up to a higher elevation than that to which it can be delivered by gravity, and the cost of construction and annual cost of operation would be greater than for sprinkling filters.

Sprinkling filters can be built at the site selected, and will give an effluent that will not subsequently putrefy. It will, however, in order to render it clear, require further treatment to remove the suspended matter, and also may require sterilization, as the bacterial purification of such filters is not high. For rendering the effluent from the sprinkling filters clear two plans are available, one being subsidence in settling basins and the other filtration through specially constructed rapidly operated filters. The filters would produce a brighter effluent than the basins, but at greater cost for construction and operation. Furthermore, at the site selected there would hardly be head enough available for their operation without pumping.

Settling basins of the Imhoff type, if properly designed for this work, would give excellent results in the final clarification of the effluent, particularly if operated in connection with chemicals to assist in hastening the work. Recent experience in Germany has shown that chemicals can be used in this connection without interfering with the efficiency of the tanks in sludge digestion.

The combination of secondary processes to produce a clear, nonputrefactive effluent, therefore, would be sprinkling filters followed by subsidence in specially designed Imhoff tanks.

For the preparatory process there is not sufficient head available to use either coarse grained filters or slate beds. Ordinary settling basins could be used, but the removal and separate treatment of the sludge depositing upon the bottom would involve difficulties and nuisances. Imhoff tanks appear to be the only available form of tanks that can be adapted to the location. These will remove enough of the suspended matter from the sewage to permit of satisfactory results with the sprinkling filters, and they solve the question of sludge reduction and removal more satisfactorily than any other process with which I am familiar. The sewage flowing to the tanks will need no further treatment than to pass through coarse screen bars, placed about 2 inches apart, and thence through a shallow, widened section of the sewer channel in which the velocity of flow will be reduced to about 1 foot per second. This channel should be long enough to give time for the silt and sand, which enters the sewers through the perforations in the manhole covers, to settle down upon the bottom.

To secure the necessary bacterial purification of the effluent, from the secondary settling basin, before discharge into the Yantzaw

River, a solution of hypochlorite of lime, or some other cheap form of sterilizer may be used.

The arrangements for using the sterilizing solution should be planned so that it could also be introduced into the effluent from the first Imhoff tank before it reaches the sprinkling filters, if desired, to prevent troublesome growths in the filters. These have occurred in certain plants, and have been cleared out and their return prevented in this manner.

Briefly, then, the type of plant best adapted to secure the quality of effluent necessary would consist of:

1. Coarse screens, about 2 inches apart.

2. Deposit chamber for silt and sand, in which the velocity of flow would be reduced to about 1 foot per second, the chambers to be 75 to 100 feet long, to secure the deposition of sand and
26 silt. This can be provided for by having three such chambers, so that one or all could be used, depending upon the volume of sewage flow and character of the sewage.

3. A set of Imhoff tanks for the removal of the suspended matters and the digestion of the sludge, the settling compartment of the tanks to have sufficient capacity to hold three hours' flow of sewage at the average rate, and the sludge compartment large enough to hold six months' accumulations of sludge. There would be 12 tanks, each about 27 feet deep and 100 feet long, in the direction of flow, holding a volume of about 4,420,000 gallons, and covering, including the channels between the beds about 1.15 acres.

4. Sprinkling filters to oxidize the organic matter in the effluent from the tanks to a stable, or non-putrefactive condition. These should have sufficient area to handle the average flow of sewage at a rate not greater than 2,000,000 gallons per acre of filter surface, per day, and could be arranged in two units, covering, including space for chambers, about 8 acres, or a tract about 500 feet wide and 700 feet long. The sewage would be sprayed over the beds from dosing tanks operating under heads varying from 2½ to 6 feet. The beds would be built up to a depth of about 8 feet of stones varying from 1½ to 2½ inches in diameter.

5. A second set of Imhoff tanks, to allow of the subsidence of the suspended matters from the effluent of the sprinkling filters, to hold about two hours' flow of sewage and to be operated with or without the use of chemicals to aid the settlement, depending upon the character of the sewage being treated, and being constructed with sludge chambers holding about 10 days' accumulations of sludge, the de-
posits in which would be pumped back to the first set of
27 Imhoff tanks intermittently, as required. These secondary tanks would be about 15 feet deep and 95 feet long in the direction of flow, arranged in 12 units having a total volume of about 2,000,000 gallons and covering an area of about 0.75 acre.

6. A chemical dosing house in which to prepare the sterilizing and precipitating chemical solutions, should it be necessary to use either one or the other or both together. The piping arrangements from this house should permit the discharge of any of these solutions, either into the sewage as it goes upon the sprinkling filters, or

into the second set of Imhoff tanks or into the effluent from these tanks before it goes into the river.

7. With the primary Imhoff tanks will also have to be arranged sludge beds for draining the water out of the sludge, and places for disposing of the sludge thus removed. The sludge beds will require an area of about one acre and should be well underdrained and covered with a surface layer of fine material.

The arrangement of the Disposal Plant, of course, is subject to modification after detailed surveys and borings have been made and after sufficient study has been given to the subject to work out the most economical plan.

Method of Operating the Plant and Results of Operation.

As before stated, the sewage will arrive at the plant in a fresh condition and will consist of ordinary town sewage diluted with clean ground water. The underlying principle in the design of the plant must be to keep the sewage in a fresh condition while separating from it the suspended matter and changing the dissolved organic contents into a non-putrescible condition. After this part
28 of the process is completed the matters temporarily retained in the sprinkling filters (which from time to time are washed out and cause the effluent to be somewhat turbid) must be separated therefrom and disposed of; and finally, if necessary, the escaping clear water must be sterilized. Further, the deposits that take place in the Imhoff tanks must be disposed of in a satisfactory manner, and there must be no odors about the place that would cause offense to people living in the neighborhood of the plant, or along the stream below.

Screens.

The screens for the plant should consist of iron bars placed in the inlet channel to the plant, about 2 inches apart and sloping at an angle of about 20° to the horizontal. These are intended to intercept and permit the removal of tin cans, bottles, boxes, boards, bricks and other large floating or heavy matters which would obstruct the slots, or the sludge outlet pipes from the Imhoff tanks. These matters removed from the fresh sewage will be small in amount, and can be readily disposed of without nuisance by burying, burning or other commonly used methods.

A photographic view of the usual type of screens employed for this purpose is shown in Figure 5.

There should be no odor whatever about this part of the works if the superintendent takes the trouble to keep the place clean.

Grit Chambers.

A velocity of flow through the grit chamber of 1 foot per second will deposit the sand, but none of the organic matter; this latter will all go to the tanks for subsidence and decomposition. Ordinarily there will be no grit or sand in the sewage. After heavy rains

a certain amount may wash in through the perforations in
29 the manhole covers in the streets of the town. This will be caught in the grit chambers and can be removed, as necessary, without nuisance. It will not give offense when dumped on the low ground below the plant, and after draining out and being rained on a few times will purify itself of the small amount of organic matter it contains, and can then be used for renewing the top surface of the sludge draining beds for the Imhoff tanks.

Imhoff Tanks.

The Imhoff tanks should be designed to give the sewage about three hours to deposit its suspended matters, and with sufficient room in the sludge chamber beneath to hold about six months' accumulations of sludge.

The plant would include 12 of these tanks. Each would consist of a settling chamber, with a sludge chamber beneath it, so arranged that the solids which are deposited in the settling chamber will slide down through a slot in the sloping floor to the sludge chamber beneath, the slot being arranged, by lapping one edge over the other, so that while the solids can pass down the gases that form when the solids decompose in the lower chamber can not rise up into the fresh sewage passing through the settling compartment over head. Scum-boards and baffleboards would be placed in each settling compartment to intercept the floating matters and secure as uniform and perfect subsidence as possible. Each tank would be arranged with inlet and outlet pipes and necessary control gates so that the sewage could be passed through the tank from either end, at will, and fill the sludge chambers uniformly. From each sludge compartment a valve-controlled emptying pipe would permit emptying the sludge upon the drying beds, as desired. Perforated water
30 pipes would also be installed in the sludge chambers, at the bottom and along the sides to assist in loosening up the sludge before emptying and to permit its agitation, if required, and a connection would be made to the sludge emptying pipe so that after emptying a tank all the sludge left in the pipe after closing the valve could be blown back into the tank and thus leave the pipe full of clean water.

The tanks should be built of concrete with very smooth surfaces and steep slopes and all the channels leading to and from them should be open and smooth so as to permit of keeping them perfectly clean and free from deposits.

In the construction of the tanks ample room should be provided for the floating matters that rise up from the sludge compartment and form a crust, or scum, over the surface.

Tanks of this type can be made either circular or rectangular in form, as best suits local conditions of economical construction, and are usually about 30 feet in depth, with conical or pyramidal shaped bottoms in the sludge compartment to keep the sludge together during its rotting. A general view of the tanks at Essen-North receiving the sewage from 180,000 people is shown in Figure 1.

During operation the sewage passes through the tank in a continuous stream, which is not interrupted thereafter, the solids in suspension settling to the bottom and sliding through the slot to the sludge chamber below. As great a proportion of the solids as can be removed economically by subsidence will drop to the bottom compartment in from one to three hours, depending upon the nature of the sewage. In some of the plants in successful operation only one hour's subsidence is necessary, while in others a longer time gives better results. Generally speaking, the proportion of the solids that can be removed from ordinary sewage, by subsidence, in periods longer than 2 hours, is so small that it does not pay to expend the necessary capital to secure the slightly higher percentage re-
31 moval, particularly as the processes adapted for further treatment can receive and treat one effluent as well as the other; and the more quickly the sewage can be passed through the settling tanks, to produce an effluent suitable for the second treatment, the less the risk of having offensive conditions about the plant.

The solids which settle out of the sewage in transit through the settling tank collect in the bottom of the sludge compartment and undergo decomposition, until reduced to a slimy black material resembling peat mud. It takes several months for this process to be completed; and the tanks, therefore, require sufficient sludge space for this to occur. Generally no sludge is drawn out of the tanks, after first being put in operation, for three or four months, or longer, depending on the rapidity and completeness with which its decomposition has gone on. After the tanks have been in operation for several months, however, the sludge is removed at more or less frequent intervals to make room for the new materials continually being deposited. The times of drawing out sludge can be accommodated to weather conditions, the sludge being allowed to accumulate, during very cold, or wet, weather until favorable conditions occur to facilitate its drying.

During the decomposition of the sludge various gases are evolved, the principal of which are carbon dioxide and marsh gases, the same that can be seen coming up through the water in swampy places where leaves, grasses, roots and other organic matters decay under the water. These gases have no appreciable odor and are liberated in too small amounts from the tanks to be detected in the air after liberation from the surface of the lisuid. The absence of the odor of sulphuretted hydrogen, which smells like rotten eggs, and is usually the principal source of nuisances from decomposing organic matter, whether garbage, sewage or other similar mat-
32 ters, is one of the marked characteristics of the decomposition which takes place in these deep settling tanks. No explanation has yet been given of the phenomenon, but that it is a fact can be attested to by all who have visited the many such tanks in operation in the Emscher Valley where they were first built and are now being introduced in increasing numbers.

It has been suggested that the absence of the odor of sulphuretted hydrogen might be due to the presence of iron, in the sewages being treated in the Emscher district, with which the sulphuretted hydro-

gen would combine and thus not be liberated as a gas, but the fact is that some of the tanks are receiving sewage of a purely domestic nature, which show, on analysis no iron, as successfully as others which contain it in large amounts. At the experiment stations established by the Cities of Philadelphia and Chicago the same results have been secured as in the Emscher district in Germany, in this regard, and the sewages treated show on analysis no more iron in solution than average normal American town sewages.

It is to be noted that non-odorous decomposition does not begin at once, but only after the tanks have been in use for two or three months. When a tank is first filled with sewage the sludge chamber, as well as the settling compartmest fills with sewage until it rises up high enough to flow out of the overflow from the tank. The whole sludge chamber is thus filled with sewage which can not get out again, and the organic matter in it, both in suspension and in solution, has to decompose and rot. During this period there may be occasions when more or less odor will be noticeable about the tanks, particularly during hot, humid weather. After this first sewage has once decomposed, however, no further odors come from the tank when in normal operation, and the water in the sludge chamber, above the sludge, is practically clear and non-odorous, and
33 covered with a crust or scum from which the only odor is a faintly tarry smell which can be detected only by turning the scum over with a fork and placing the nose close to it. At least this has been my experience at these works. After a state of equilibrium has been reached no more fresh sewage enters the sludge compartment excepting such quantities as may be required to make up for the volumes of sludge drawn out from time to time.

Owing to the method of constructing the tanks the gases which are evolved in the sludge chamber, in excess of what the liquid in the chambers will dissolve at the prevailing temperatures and pressures where dissociated during decomposition, rise up through the liquid and are deflected by the underside of the sloping bottom of the settling compartment, and issue to the air through the sludge space without passing through the fresh sewage flowing through the settling compartment. This prevents the contamination of the fresh sewage with the rotting particles carried up by the bubbles in the sludge chamber and allows the settled sewage to flow through and out of the tank still in a fresh condition.

Sometimes, particularly after having been in operation but a short time, and when silt and sand are allowed to go into the tanks, the sludge solidifies in the bottom of the sludge chamber and the liberated gases, accumulating thereunder, lift large pieces up which may choke the slot and prevent the entrance of the solids deposited from the fresh sewage. When this occurs it is necessary to draw off some of the partly decomposed sludge and clear the slot; this operation is attended with more or less odor, but is a condition which rarely occurs and which can be prevented by an alert attendant, and, if occurring, can be remedied by simple and effective measures. It does not occur in well designed and properly operated tanks.

The formation of gases in the sludge chamber is of much
34 importance in facilitating the handling and drying of the sludge. As is well known, the quantity of gases water will dissolve, other things being equal, is proportional to the pressure. The gases which are liberated in the bottom of the tank are dissolved under a pressure of about 30 feet of water, or about one atmosphere in addition to the atmospheric pressure. When this water, containing the gases dissolved under this pressure, is brought up to the surface at atmospheric pressure, the gases can no longer be held in solution and are *occluded* in the form of fine bubbles. The ordinary siphon of carbonated water is a familiar example of this phenomenon. These waters are charged with carbonic acid gas under heavy pressure and the water takes the gas in solution. As soon as some of the water is drawn from the siphon the pressure of the gas on the surface of the water in the siphon is reduced, and bubbles form in the water and continue to rise to the surface until equilibrium of pressures and quantities held in solution is again established, when the bubbles cease to form and the water becomes quiet.

This is the case when the liquid sludge is drawn from the bottom of the Imhoff tank. As soon as the sludge valve is opened the weight of the water above the value forces the sludge up through the sludge pipe, the outlet of which is lower than the surface of the water in the chamber, and the sludge flows out of the pipe charged with gases under pressure. When it reaches the air these gas bubbles expand and loosen the sludge up to a spongy porous condition. The mass is sticky, at first, and it apparently stiffens up, on the sludge draining beds, with the spaces formed by the gas bubbles preserved in the form of pores and open spaces. This greatly facilitates the process of drying, allowing the water contained in the liquid sludge to drain out so freely that ordinarily the sludge can be handled with shovels, like moist soil, a few days after being discharged upon the beds.

35 Last July I visited the plant at Recklinghausen, which treats the sewage of 26,000 people, two days after sludge had been discharged upon the beds from one of the tanks, and it was then dried out so that cracks covered the surface; it was shoveled from the beds the next day and wheeled in push-cars to the dump close at hand. I remained about the plant for some time examining the works, the character of the incoming sewage, the effluent from the works, the fresh sludge drawn from the sludge chamber at my request, the partially drained sludge on the sludge beds, the water draining from the sludge beds, the channel that had been receiving this water for several years, and the piles of sludge that had been removed from the beds in the past, and I could not find any odors about the place, except the smell of new mown hay that was being cut in fields several hundred feet away. This plant had been in continuous operation since the Fall of 1905. A photographic view of the Recklinghausen plant is given in Figure 3.

I visited the works when they were being operated under ordinary every day conditions, and not in anticipation of visitors, having gone

there without appointment. My visit was unexpected until I called upon Dr. Imhoff at his office in Essen and asked to be allowed to go down to the plant at once. The works were then receiving the sewage of about 26,000 people and was hemmed in with shrubbery on a piece of ground which seemed to be not over an acre in area. No attempt is made there to treat the sewage further than by the tanks, the effluent from which is conducted to an open concrete lined channel leading down, eventually, to the Rhine.

The sludge accumulations at this plant, after five years of operation, were insignificant in volume, as farmers in the vicinity come and take it away, paying a small price per load for it. I doubt if its manurial value is high, but its spongy, light nature makes
36 it useful for plowing into heavy soils to render them more porous and more easy of cultivation.

Sprinkling Filters.

From the Imhoff tank the sewage will be conducted to a series of automatic flush tanks, which will discharge the sewage intermittently in a spray over the surface of the filters.

The filters will be built in beds with concrete floors draining to a general collecting channel leading to the secondary settling tanks. The filters will be built up of coarse gravel, or stones, from about 1½ to 2½ inches in size, and thoroughly underdrained with special tiles to permit the free passage of air entirely through the beds from top to bottom.

Such filters, when the rate of operation is properly adjusted to the character of the sewage, the depth of the filtering materials and the areas of the beds, will change the organic matters in the sewage to a condition not subject to subsequent putrefaction. When the sewage sprayed upon the filters is fresh no offensive or objectionable odors result, but when septic or rotten sewage is sprayed into the air the sulphuretted hydrogen and other gases escape, and may be carried by the winds for some distance, and create very offensive conditions, particularly in the immediate neighborhood of the plant.

The processes which go on in sprinkling filters, when properly designed and operated, produce no odors, as no slow decomposition goes on in the beds. The action is rapid and is brought about in the thin films of sewage flowing slowly over the surfaces of the stones in complete contact with the air, and the effluent from the filters, while more or less muddy in appearance, has no smell and will stand for a long time as inoffensive as ordinary gutter water in the streets after a rain. A small plant which I built last
37 year from the Pennsylvania Chautauqua Grounds, at Mt. Gretna, along lines somewhat similar to those proposed herein for Orange, Montclair and East Orange was shut down for the season during the early part of September, but the settling basins which had received the effluent from the sprinkling filters all summer were left standing full. I visited the works after this water had been standing for two weeks exposed to the sun and air, and it was then clear, without odor and like ordinary pond water, support-

ing on the surface a growth of green algae, and showing no signs of gray sewage fungi either in these basins or the channels leading from the sprinkling filters, and no odors were detectable about the filters. Stones dug up from some distance below the top of the filter had an odor such as if it had been just dug up from the ground; all traces of odors of putrefaction were absent. I am informed by people who repeatedly saw the plant in operation during the hot summer weather that there was no odor about the place except where a leaky valve from one compartment of the sludge chamber allowed a continual escape of a small amount of decomposing sludge. This was so small that the odor could not be noticed except in the immediate vicinity of the sludge bed upon which it flowed.

The Pennsylvania State Board of Health requires daily reports of the operation of this plant, and these show that no sample collected during the time the plant was in operation showed putrescibility when kept in stoppered bottles for 5 days, the stipulated time for the test. The superintendent kept several samples for much longer times, for his own information, one for two weeks, and it was still stable when he was obliged to throw it away for lack of bottles.

Secondary Settling Basins.

38 After passing through the sprinkling filters the sewage will go to the secondary settling basins or Imhoff tanks for the deposition of the suspended matters draining from the filters. The tanks would be built with much smaller sludge compartments, than the primary tanks and the deposits taking place therein would be pumped back, as required, to the primary Imhoff tanks, by a small pumping plant.

Machinery and Chemical House.

At a convenient location, probably near the primary and secondary Imhoff tanks, there will be a house containing the pumps for pumping the deposits which gather in the secondary Imhoff tanks to the inlet channel leading to the primary Imhoff tanks. The accumulations in these secondary tanks will be pumped out, as required, and after complete digestion in the primary Imhoff tanks be discharged upon the sludge beds. The service required of the pumps will be intermittent, and their period of operation short, so that elaborate machinery will not be required. The pumps could be driven by electric current, if this could be conveniently secured, or by gasoline engines.

In this house would also be located tanks for making up the necessary chemical solutions and devices for regulating the amounts to be used in accordance with the necessities of the case. Pipes from the house would lead to the various points where the chemicals would be introduced into the sewage.

Water Supply.

A supply of clean water will be essential at the plant for keeping the place clean and for making up the chemical solution. Water

may be had at this point by a connection with street mains about one-half a mile away, or, if preferred, an independent supply can be put in, taking water from the ground by means of a deep well, or a filtered supply sufficient for the needs of the plant could
39 be taken from the river. There would not be a great deal of difference in the cost of these methods, of getting a water supply.

Superintendent's Residence.

It will be advisable to have a well appointed house for the residence of the superintendent of the plant, who should be a man of experience and ability. It is possible that one of the houses now located on the site proposed for the works could be utilized for this purpose after remodeling. I have, however, included in the estimates of cost a sum sufficient to erect a new residence with proper water supply and plumbing.

General Maintenance of the Works.

After the works are completed it will be essential that not only the disposal plant, but also the trunk sewer and all the sewers in the towns of Orange, Montclair and East Orange be kept clean and in good repair in order that the sewage may be fresh when it arrives at the disposal works. To accomplish this end I would strongly recommend that the three cities appoint a commission to have charge of the construction of the disposal works and connecting sewers, and, after the works are built, to have charge of the operation of the process of purification and also of the maintenance and cleaning of the sewers in each of the three towns, as well as the main outfall sewer leading to the works.

The reason for this recommendation is that even though the disposal plant may be all that could be desired in the matter of design and construction, the superintendent of the disposal works might be greatly embarrassed if, through the neglect of any of the towns to keep the local sewers in repair, and properly clean, foul smelling sewage might arrive at the plant and give rise to disagreeable odors in the vicinity of the plant. If the entire sewerage works of the three towns are under the direction of a joint committee who
40 holds the superintendent of the disposal works responsible for their inodorous operation there would certainly be no odors detectable at the plant after it has once been put in proper and successful operation.

Estimates of Cost of Construction and Operation.

Based upon the data regarding the quantity of sewage to be treated and the general type of plant above described, I estimate the cost of construction to be as given in Table V.

TABLE V.

Estimated Cost of Constructing Sewage Disposal Works for Orange, Montclair, and East Orange (Including 15% for Engineering and Contingencies).

Population to be Provided for in First Installation, 133,000 (Estimated to be Reached by 1925).

Items.	Proportion of total cost of construction to be charged to each city on the basis of maximum rate of sewage flow in 1940.			Total Cost.
	Orange. (31.6%)	Montclair. (32.0%)	East Orange. (36.4%)	
Land for disposal works....	$39,500	$40,000	$45,500	$125,000
Joint sewers:				
From plant to junction of East Orange sewer.....	36,340	36,800	41,860	115,000
From East Orange sewer to junction of Orange and Montclair sewers	19,276	19,520	22,204	61,000
Purification works, including grit chambers, Imhoff tanks, sprinkling filters, secondary tanks, machinery and chemical house, water supply, sludge beds, piping connections, superintendent's house, grading, planting, etc.....	259,120	262,400	298,480	820,000
Totals	$354,236	$358,720	$408,044	$1,121,000

When the capacity of these works shall have been reached, 41 additional filters, tanks and sludge beds will be necessary. As these will not be required, however, for many years, the money necessary for their construction would not have to expended at the present time and the cost of such extensions, therefore, when required would be represented by the present worth of the money. The probable cost of these extensions would be about $188,000, but deferring the construction for 14 years (1911 to 1925) would give a present worth, interest at 4%, of $109,000.00, which, with 15% added, would be about $125,000.

The final cost of construction, therefore, for a population of 181,000, which is estimated to be reached by 1940, with the relative costs distributed to the three towns in the same ratio, as above, would be as given in Table VI.

TABLE VI.

Items.	Orange. 31.6%	Montclair. 32.%	E. Orange. 36.4%	Total.
Cost of first installation of works, as above.....	$354,236	$358,720	$408,044	$1,121,000
Present worth of new extensions in 1925, to serve until 1940	39,500	40,000	45,500	125,000
Totals	$393,736	$398,720	$453,544	$1,246,000

The annual cost of operating and maintaining the works would be made up of the interest on the cost of building the works, an allowance to provide for a sinking fund to retire the bonds, an allowance to cover the depreciation of the works, the salaries paid for labor, and the cost of fuel, chemicals and general supplies.

In the following estimates I have calculated the interest at 4½ per cent. and the sinking fund at 2 per cent. of the cost; the depreciation amounts are based on annuities sufficient to replace the perishable parts of the works at the end of their assumed usefulness; the items for labor include a superintendent and ten men,
42 who are to have charge of the works and the maintenance of the sewers in proper sanitary condition. The items of fuel, chemicals and supplies are based on the quantities of each which I estimate will be necessary. On the above basis the annual cost of operation would be as given in Table VII.

TABLE VII.

Annual Cost of Operation and Maintenance for a Population of 133,000.

(Estimated to be Reached by 1925.)

Items.	Orange.	Montclair.	East Orange.	Total.
Interest at 4½%	$15,941	$16,142	$18,362	$50,445
Sinking fund at 2%	7,085	7,174	8,161	22,420
Depreciation	790	800	910	2,500
Labor	3,100	3,200	3,640	10,000
Fuel, chemicals, etc.	3,100	3,200	3,640	10,000
Totals	$30,136	$30,516	$34,713	$95,365

For a Population of 181,000.

(Estimated to be Reached by 1940.)

Items.	Orange.	Montclair.	East Orange.	Total.
Interest and sinking fund	$25,593	$25,917	$29,480	$80,990
Other items	8,535	8,643	9,832	27,010
Totals	$34,128	$34,560	$39,312	$108,000

For the purpose of showing the relative costs of constructing and operating the plant recommended with the costs to the three cities under the plan proposed by the Passaic Valley Sewerage Commission in their report of 1908, I have arranged, from the data given in that report, the costs of construction, as given; and the annual costs of operation, with interest and sinking fund at 6½ per cent. and the other operating costs in the proportion of the use these towns would make of the sewer (as stated in the report) to the total capacity of the sewer, or, in the ratio of 37 to 360. This gives a cost
43 of $124,567 for interest and sinking fund and $29,000 for the other items, or a total, by 1940, of $153,567.

On these bases, the costs of construction of works sufficient for the population to be expected by 1940 would be as follows:

Estimated Construction Costs to Orange, Montclair, and East Orange of Joining in the Passaic Valley Sewer Project.

Cities.	Orange.	Montclair.	East Orange.	Total.
Costs	$418,800	$600,649	$898,871	$1,916,410

Estimated Annual Costs to Orange, Montclair, and East Orange of Joining in the Passaic Valley Sewer Project.

Cities.	Orange.	Montclair.	East Orange.	Total.
Fixed Charges	$39,363	$39,861	$45,343	$124,567
Other Items	9,164	9,280	10,556	29,000
Totals	$48,527	$49,141	$55,899	$153,567

A comparison of these figures with those for the plan recommended herein shows that it will cost the three cities nearly $670,000 more to join in the Passaic Valley Sewer project than to build a local disposal plant, and nearly $50,000 per year more to meet the necessary operating expenses of the Passaic Valley Sewer than of the plant recommended.

General Summary.

The plant recommended in the foregoing description, with extensions about 1925, will provide for the purification of the sewage of Orange, Montclair and East Orange until the population of these towns shall have reached about 181,000 people, which, I estimate, will be by 1940. All parts of the first installment of the works would be built to take care of a population of about 133,000
44 people except the sewers leading to the plant, which should have capacity sufficient for the population that will be reached by 1940. In the estimates of cost the sewer from East Orange is not included for lack of data as to its course. I have satisfied myself, however, that a sufficient head would be available, from the East Orange town line to the junction with the trunk sewer, to permit of the conducting of the East Orange sewage to the plant in a sewer having a self-cleansing grade.

If maintained with average care, and with an understanding of the nature of the processes to be carried out, and the proper methods of caring for the different portions of the works, the plant should prove a success in every way, and be devoid of objectionable features. The works will be situated in the low ground lying back from the Yantecaw River, and would be surrounded by hills rising up rather steeply from the valley to a height from 50 to 100 feet above the plant. On all sides except at one small corner, the tract of ground is covered with large trees that will hide it from view from the roads traversing around the district. The nearest houses to the plant at

present, except those situated on the tract where the works will be built, are about 1,000 feet away, and there are but two or three of these, and they lie in a position where the prevailing winds will blow towards the plant. By purchasing the tract of land outlined and preserving the trees thereon, and improving the landscape features of the situation by planting trees, shrubbery and flowers, the works could be made very attractive, and would become a centre of much interest for visitors.

There would be no odors connected with the spraying of the fresh sewage upon the sprinkling filters, and none connected with the handling of the sludge from the Imhoff tank, judged by the experience that has been had at other places dealing with stronger sewages of the same general character.

45 The effluent from the plant would go into the Yantecaw River, at all times, in better condition than the waters of the river, and would contain nothing that would injuriously affect any uses to which the water would properly be put for manufacturing or trades uses, or for its enjoyment in any proper way. The discharge of this effluent into the river would not cause the water to become foul, even though several times as great in volume as the river water during dry weather; it would, in fact, be a decided advantage to the river, and to the parties along the stream below, to have the additional flow during dry weather. On the other hand, during flood flows the increase due to the discharge of the effluent in the river would not perceptibly increase flood heights.

As to the absence of nuisance around installations of properly designed Imhoff tanks the best evidence is to be found in and around the City of Essen, Germany, where numerous such plants are situated in densely populated districts. By reference to Figure 1, which is a photograph of the Essen-North plant, it will be seen that directly back of the works is a row of large buildings, several stories in height. These stand about 500 feet from the tanks treating the sewage from 180,000 people, and are high class apartment houses. Figure 3 shows the plant at Recklinghausen, which receives the sewage from 26,000 people. This little plant stands on an area considerably less than an acre in extent, the area of the tanks being 0.05 acre and of the sludge drying beds 0.10 acre. The house close beside the plant is the residence of the superintendent of the works. On the opposite side of the works from the superintendent's house and, as I recollect the location, not more than 500 or 600 feet away, is a very fine detached residence; others are located around the same general neighborhood at various distances from the works, as can be seen in Figure 4. No complaint has ever

46 been made of odors at this plant, nor could I learn of anyone living in the vicinity who had found anything to object to about the works.

Figure 2 shows the sludge beds of the plant at Bochum, which receives the sewage from 150,000 people. High class residences surround the works, those shown being 400 to 500 feet away from the sludge beds.

At the time of my visit, when fresh sludge was drawn from the

tanks at my request, when freshly drawn sludge had been drying upon the sludge beds close beside the tanks for two days and when piles of dried and partially dried sludge were scattered about, a few hundred feet below the works, I could detect no odors about the place arising from the works or their operation. A view of the sludge beds at the Recklinghausen plant is given in Figure 4, and of those at Buchum in Figure 2. The houses shown near the sludge beds at Bochum are about 400 to 500 feet away.

Regarding the sprinkling filters, there is less definite information as to their inodorousness than about the Imhoff tanks. Unfortunately, all the large installations of sprinkling filters which I have visited are receiving septic or rotten sewage, and at most of these, though not all, there was more or less odor detectible at distances of from 200 feet to one-half mile, or more, depending upon the humidity, temperature, direction of the wind, and rottenness of the sewage. There are one or two plants in Europe of moderate size, which are handling fresh sewage, and in these the experience has been similar to the Mt. Gretna plant, in that the fresh sewage has not caused any odors at the sprinkling filters. Another curious circumstance is that at all these plants handling fresh sewage it has been noted that the small flies which are so abundant around most sprinkling filter plants have not, so far, appeared.

It is not necessary, in this report, to enter into a discussion
47 of the chemical and biological aspects of the treatment proposed herein, as I believe that you are more interested in securing my profesional judgment as to the general satisfactory condition of such a plant.

It is my judgment that there will be no difficulty in building and operating the plant recommended, in such a manner that it will not produce disagreeable odors at the plant, or in its vicinity, or along the Yanteeaw Valley; or cause the Yanteeaw River to be less desirable, at any time for any use to which it can now be put; or in any measurable degree increase the heights of floods in the river.

Respectfully,

JAMES H. FUERTES.

(Here follow figs. 1 to 5, marked pages 48 to 52, Complainants' Exhibit No. 137.)

Exhibit-137



Fig. 1. Imhoff Tanks at Essen-North (Germany)
Population 180,000
Note Proximity of Dwellings.

Exhibit 137



FIG. 2. Sludge Beds at Bochum (GERMANY)
POPULATION 150,000
Area of Beds—0.6 of an Acre.

Exhibit 137



Fig. 3. Imhoff Tanks at Recklinghausen (Germany)
Population 30,000
Note Dwelling in Background

Exhibit 137

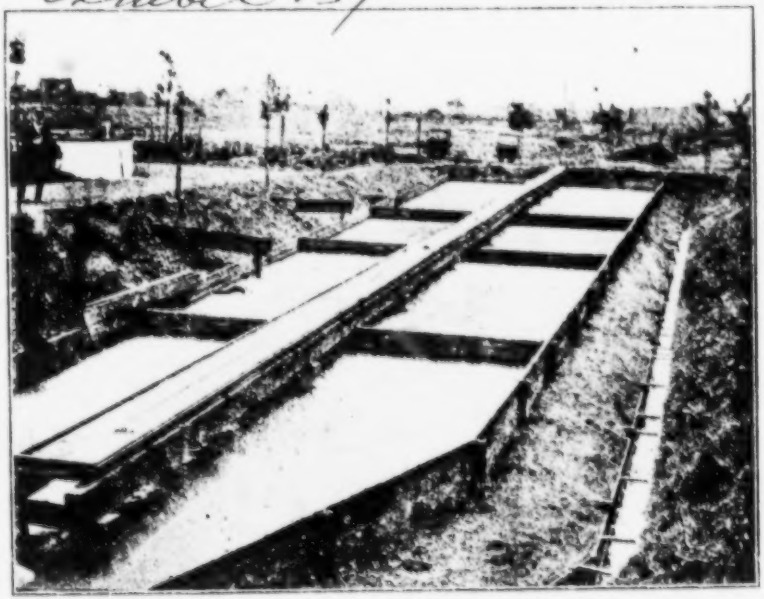


FIG. 4. Sludge Beds at Recklinghausen (GERMANY)
Area of Beds—0.1 of an Acre.
Beds are Located Between Tanks and Dwelling.

Exhibit 137



Fig. 5. Screens and Grit Chamber at Essen-North (Germany).

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

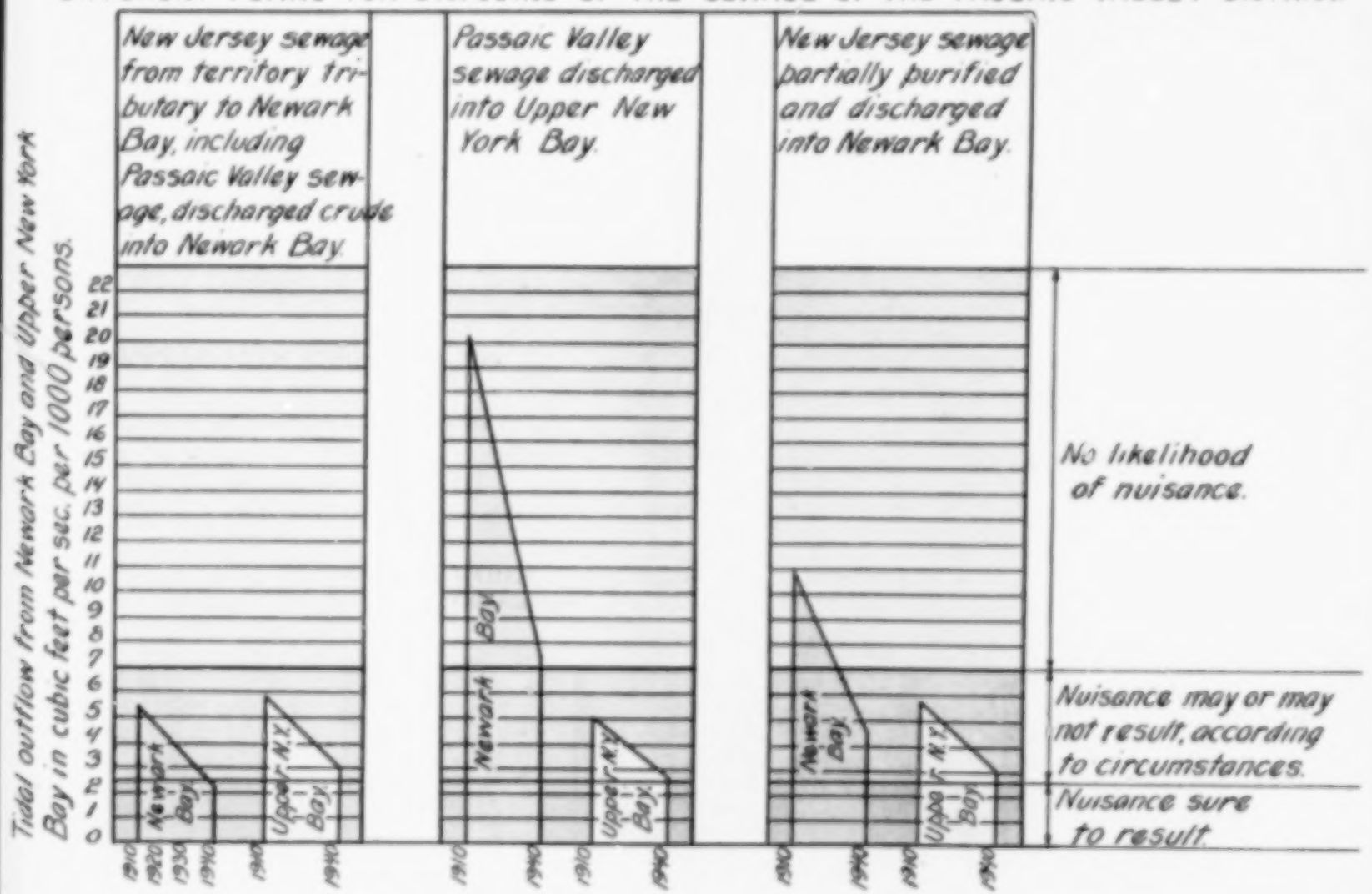
COMPLAINANTS' EXHIBIT No. 138.

Showing Estimated Relative Pollution of Newark and Upper New York Bays Under Different Plans of Sewage Disposal.

JAMES D. MAHER,
Commissioner.

Conformed to Exhibit No. 138
James D. Waters
Commissioner

ESTIMATED RELATIVE POLLUTION OF NEWARK AND UPPER NEW YORK BAYS UNDER DIFFERENT PLANS FOR DISPOSING OF THE SEWAGE OF THE PASSAIC VALLEY DISTRICT.



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 140.

Showing Condition of Water at Harrisburg, Pa., in 1903.

JAMES D. MAHER,
Commissioner.

Board of Public Works, Harrisburg, Pa. Color of Turbidity of Susquehannah River under center of spans of Walnut Street Bridge, Harrisburg, Pa, on certain days in 1903.

Table No. -showing Colors of Turbiaities of Samples- mathematically Expressed.

(The figures repusent per cent. which each color has in compound or fused color by color-top method)

Sample Number	Station on River	Gauge Height	Sediment							Turbidity							Red							Yellow							White							Black						
			Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16	Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16	Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16	Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16	Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16	Mar. 1	Mar. 3	Mar. 24	Mar. 25	Mar. 26	Mar. 27	Apr. 16
	No. ½		½"	½	clear	clear	clear	clear	clear	1000	850	550	150	800	250	170	5	32.5	3	14.5	22	12.5	6	5	23	3	8	23	17	4.5	2	10	0	6	12	6.5	3.5	88	34.5	94	71.5	43	64	86
	No. 1		1"	½	clear	clear	clear	clear	clear	1200	950	500	500	800	250	170	6.5	33	6	14.5	22	12.5	6.5	5.5	23	3	8	23	17	4.5	1.5	8.5	0	6	1.05	6.5	5	86.5	35.5	91	71.5	41.5	64	89.5
	No. 1½		1"	½	clear	clear																																					
	No. 2		1"	½	clear	clear	clear	clear	clear	1600	1000	450	450	1000	280	150	8	32.5	2	22	30	19	10.5	6.5	23	23	12	23	14	8	4	10	0	8	10	7	8.5	81.5	34.5	95.5	58	37	55	73
	No. 3		1"	½	clear	clear	clear	clear	clear	1700	1100	180	450	1500	280	140	16.5	32.5	5	28.5	31	19	14.5	11.5	20	4.5	12.5	24	24	13.5	3	0	3	7.5	12	8	9.5	69	37.5	87.5	56.5	33	40	60.5
	No. 4		1"	½	clear	clear	clear	clear	clear	1800	1100	170	450	1400	270	140	30	32	10	27	31	18.5	19	15	23	15	14.5	24	24	15	3.5	9	9	9	12	9.5	13	56.5	36	66	40.5	33	48	53
	No. 5		1"	½	clear	clear	clear	clear	clear	1800	900	110	450	1300	260	100	33	34.5	13	30	31	22.5	19	16	20.5	18	17.5	24	22.5	15	5.5	8	10.5	8	12	9	13	45.5	37	58.5	44.5	33	46	53
	No. 6		1"	½	clear	clear	clear	clear	clear	1500	850	110	450	1300	250	160	33	30.5	13	33	31	24	20	18.5	24	18.5	18.5	24	24.5	17	7	9	12	8	12	10.5	14	41.5	36.5	56.5	40.5	33	41	49
	No. 7		1"	½	clear	clear	clear	clear	clear	1250	750	110	1000	1350	200	190	42	32.5	13	34.5	30	22.5	20	18.5	24	18.5	20	23.5	20	17	4.5	9	12	8	12	8.5	14	35	36.5	56.5	37.5	34.5	46	49
	No. 8		1"	½	clear	clear	clear	clear	clear	1000	660	90	400	1100	200	200	42	30.5	13	34.5	30	20	23.5	18.5	24	18.5	20	23.5	24	16	7	9	12	8	11	11	10	32.5	36.5	58.5	37.5	25.5	45	50.5
	No. 9		1"	½	clear	clear	clear	clear	clear	900	600	140	400	900	170	220	42	29.5	13	34.5	30	18.5	23.5	20.5	23	18.5	20	23.5	24	16	5	10.5	10	8	11.5	12	10	32.5	37	58.5	37.5	35.0	43.5	50.5
	No. 10		1"	½	clear	clear	clear	clear	clear	800	500	170	350	750	130	250	41	29.5	27.5	36.5	30	20	29.5	23.5	23	19	21	4.5	27	16.5	7.5	10.5	10	8	11.5	10	9.5	28	37	43.5	34.5	35	43	44.5
	No. 11		1"	½	clear	clear	clear	clear	clear	900	450	220	300	550	110	300	36.5	29.5	35.5	41.5	30	19.5	32	24	23	20	22	23.5	28	16.5	9	10.5	10	8	11.5	12	9.5	30.5	37	34	29.5	35	40.5	42
	No. 12		1"	½	clear	clear	clear	clear	clear	1000	400	260	350	350	85	350	36.5	29.5	34	40.5	48.5		32	24	23	20.5	22	24		16.5	8	10.5	10	8	10		9.5	31.5	37	35.5	29.5	21.5		42
	No. 13		1"	½	clear	clear	clear	clear	clear	1100	400	280	450	500	110	350	37	29.5	32.5	41	41.5	19	32	24	23	20.5	21.5	28	27.5	16.5	7.5	10.5	10	8	12.5	8	11	31.5	37	37	29.5	18	40.5	40.5
	No. 14		1"	½	clear	clear	clear	clear	clear	1300	400	290	500	500	120	400	34.5	30.5	31.5	39.5	41.5	19	32	24	24	21.5	22	27.5	27.5	11.5	8	9	10.5	9	11.5	12.5	11	33.5	36.5	36.5	29.5	19.5	41	40.5
	No. 15		1"	½	clear	clear	clear	clear	clear	1600	350	350	500	550	120	900	31	29.5	31.5	37.5	43	15	32	29	23	21.5	22	26	25	19.5	8	10.5	19.5	9	11	15.5	11	32	37	36.5	31.5	20	44.5	37.5
	Gauge Height		13.4	14.5	9.4	15.2	14.2	11.0	12.7																																		

Complainants Exhibit No. 140

James D. Maher

Examiner

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

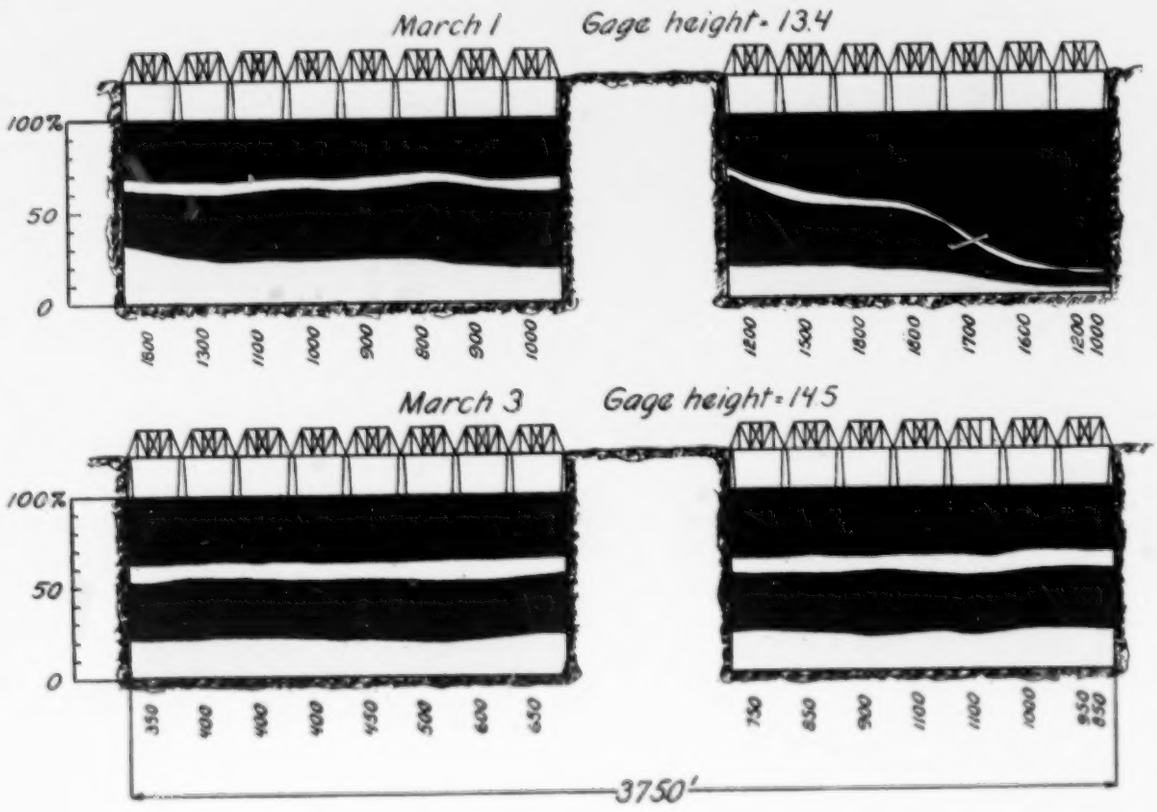
COMPLAINANTS' EXHIBIT No. 141.

Showing Color of Turbidity of Susquehanna River Water at Harrisburg, Pa., in 1903.

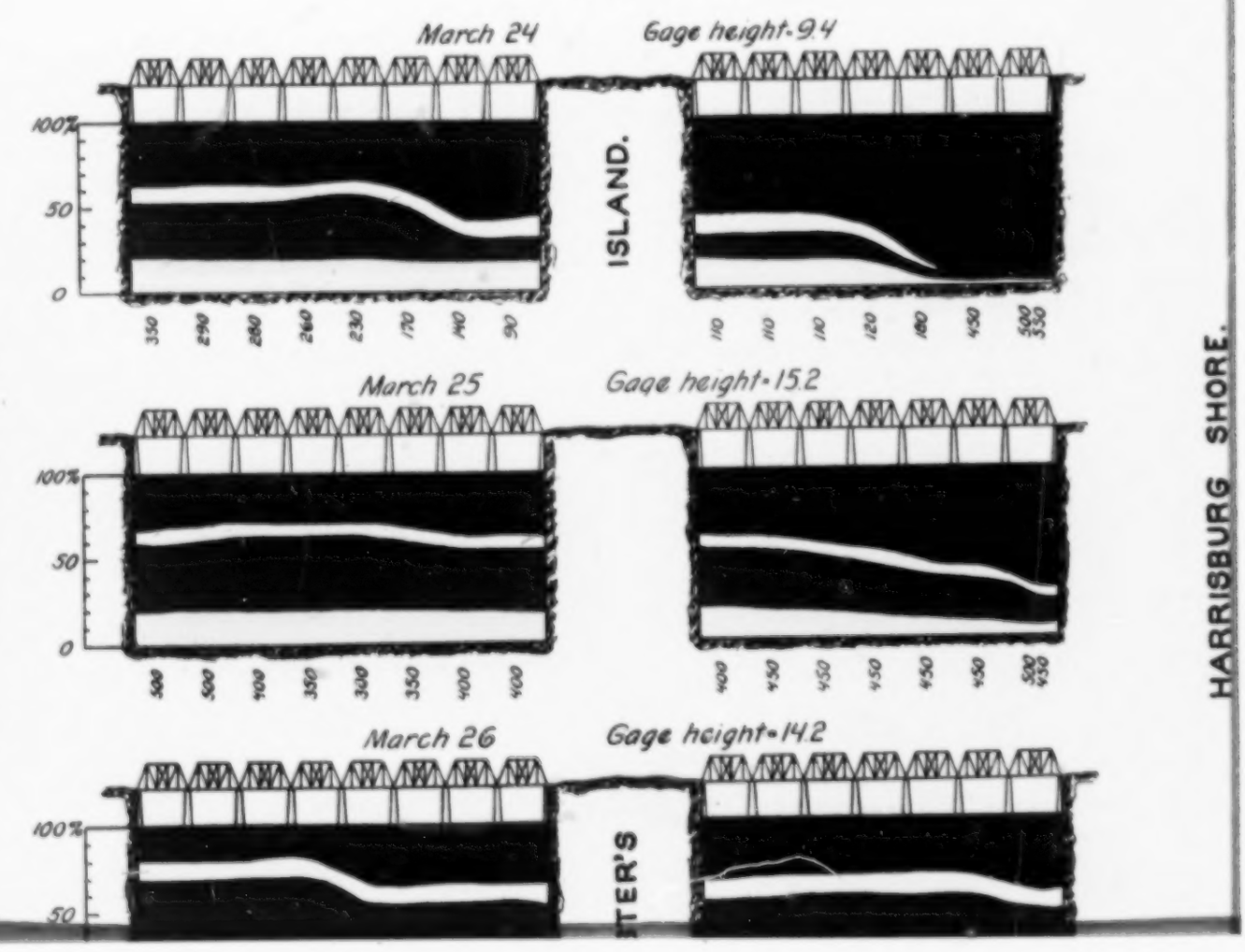
JAMES D. MAHER,
Commissioner.

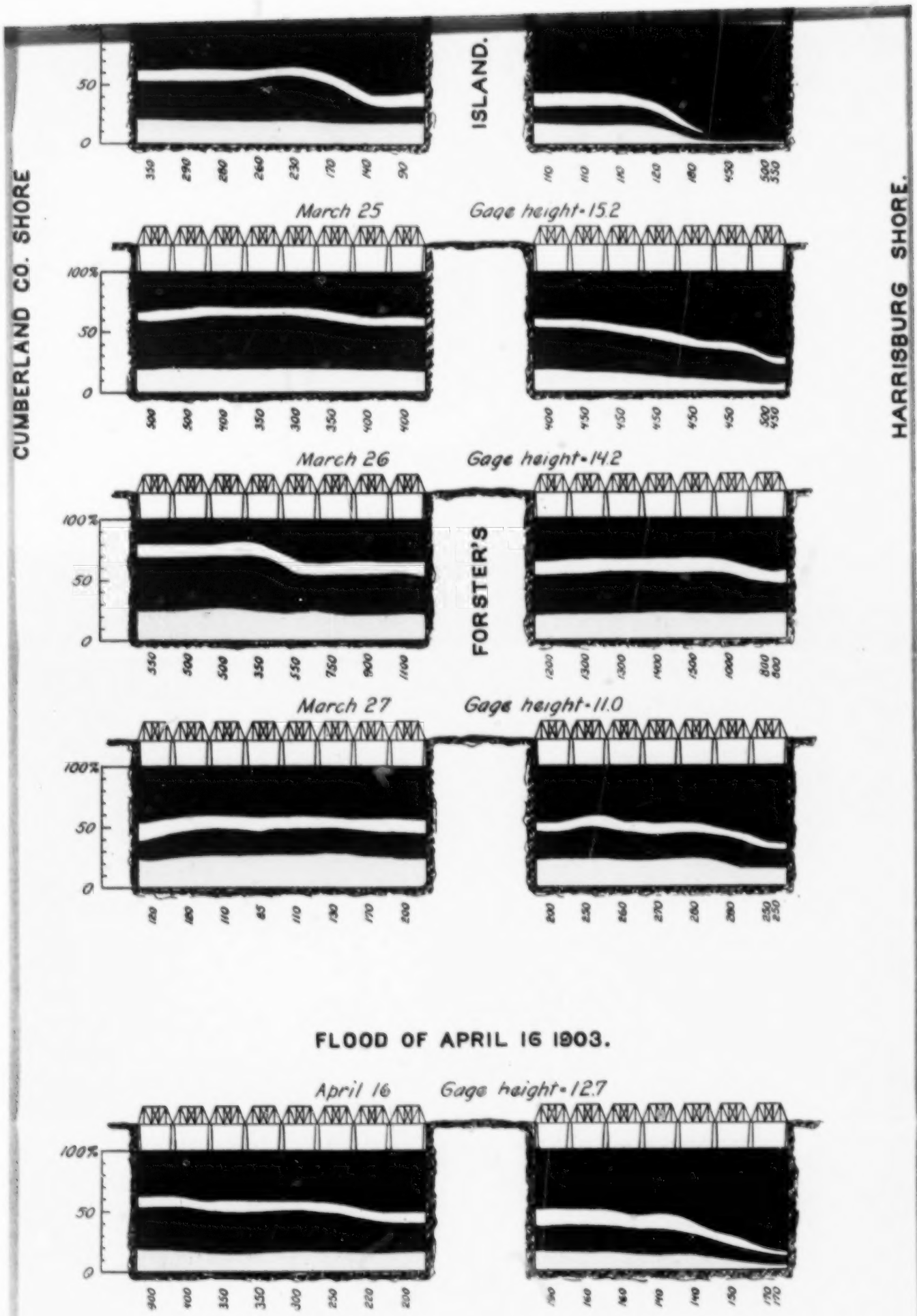
Complainants Exhibit No. 141
James L. Maher
Commissioner

FLOOD OF MARCH 1 1903.



FLOOD OF MARCH 24 1903.





FLOOD OF APRIL 16 1903.

COLOR OF TURBIDITY OF SUSQUEHANNA RIVER WATER AT HARRISBURG PA. ON CERTAIN DAYS.

Samples taken under each span of Walnut Street Bridge Component colors, black, red, yellow, and white, plotted in percentages of fused color Percentages obtained by color top. Figures are silica turbidities.



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 142.

Showing Map of Belfast Lough, Ireland.

JAMES D. MAHER,
Commissioner.

Complainants Exhibit No. 102
James D. Maher
Commissioner



MAP OF

BELFAST LOUGH

SHOWING POSITION OF SEWER OUTFALL
AND LOCATION OF GROWTH OF ULVA LATISSIMA

FROM ROYAL COMMISSION ON SEWAGE DISPOSAL
FIFTH REPORT, APPENDIX VI, FACING PAGE 237

1 COMPLAINANTS' EXHIBIT No. 145. James D. Maher, Commissioner.

NEW YORK CITY, May 19th, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Report on the Discharge of Sewage from the Proposed Passaic Valley Sewer of New Jersey.

Metropolitan Sewerage Commission of New York.

May 23, 1910.

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: In a report submitted by this Commission to your Honor on March 1, 1910, reference was made to a number of proposed trunk sewers which will add materially to the pollution of the harbor by carrying the sewage of inland cities to the immediate vicinity of New York City for disposal. One of these sewers is that of the Passaic Valley Sewerage Commissioners, of New Jersey. To prevent the execution of the Passaic Valley project a suit is pending in the United States Supreme Court between the People of the State of New York, complainants, and the State of New Jersey and Passaic Valley Sewerage Commission as defendants.

The United States Government by permission of the Court became a co-plaintiff in this suit, but has recently entered into an agreement with the defendants whereby the objections of the Government have been removed. It is expected that this agreement will be followed by the withdrawal of the State of New York, thus permitting the construction of the Passaic Valley sewer and the discharge of its sewage after partial purification, into Upper New York Bay.

The Metropolitan Sewerage Commission has given close attention to the Passaic Valley project since 1906. The question was also studied by the New York Bay Pollution Commission from 1903 to 1906. The Pollution Commission objected to it in general and specific terms, and recommended that the State of New
2 York bring action which is now pending in the Supreme Court of the United States to prevent the execution of the proposed works.

The plans for the works have been altered somewhat since this suit was begun, but they have not been wholly relieved of their objectionable features. The Metropolitan Sewerage Commission respectfully advises your Honor that the project as now announced should be opposed by the City and State of New York as involving serious danger of nuisance and injury to the public health.

Upon its face the present plan of the Passaic Valley Commis-

sioners appears to be a decided improvement upon the project formerly announced, but it is the opinion of the Metropolitan Sewerage Commission that the method of disposal is still objectionable. The degree of purification is insufficient. There are features connected with the outlets which are untried, experimental and of uncertain practicability. The agreement provides for the enforcement of the contract by the United States War Department instead of by the City or State of New York or an Interstate Commission, where jurisdiction over the sanitary condition of the harbor properly belongs.

Plan of the Passaic Valley Commissioners.

The proposition of the Passaic Valley Sewerage Commissioners is to collect the house drainage of Newark, Paterson, and about 30 other municipalities or townships in the Passaic Valley and discharge it into Upper New York Bay. This would be done by an extensive system of sewers and a tunnel running under Newark Bay, Bayonne and New York Bay to the neighborhood of Robbin's Reef. The tunnel would discharge the sewage through a number of outlets at the bottom of the harbor near the edge of the main ship channel. The sewage would be screened and passed through settling basins in order to remove solid particles of grit. The number of persons tributary to the sewer would be about 600,000 when the works were first put into operation. The quantity of sewage would increase with the population up to the full capacity of the sewer, when there would be about 1,650,000 people contributing their sewage to the works.

Insufficient Purification.

The purification intended would not be sufficient to admit of the discharge of the Passaic Valley sewage at Robbin's Reef. The process contemplated is designed solely to remove solid matters, and has no reference to the dissolved organic matters which may be present and from which a large part of the total nuisance may be anticipated. There will be little solid matter to be removed from the sewage. Owing to mechanical and biological actions in the sewer much of the solid matter will be broken up into extremely fine particles which will escape the screens and settling basins and pass into the harbor water.

Even the removal of a very large percentage of the suspended matter in the sewage would not purify the sewage to a satisfactory extent. Most of the organic matter in all sewage is present in dissolved form. Because of its long passage through the sewers the sewage will, in all probability, be in a septic, or rotten, condition and consequently very offensive.

Owing to its septic condition the sewage will have a great avidity for the oxygen dissolved in the harbor water, and the investigations of this Commission indicate that the supply of oxygen in the harbor is already deficient because of the sewage which is being discharged.

The discharge of so large a quantity of sewage into the harbor in one locality, even though the outlets be scattered over an area of several acres, would almost certainly result in the reduction of the dissolved oxygen at times of imperfect dispersion, and during times when the currents would be stationary or recently reversed, to so low a point as to invite putrefaction and the consequent evolution of foul odors from the water and sewage mixture. In this connection it should be remembered that the point of outfall would be in the land-locked part of the harbor, within sight of the most densely crowded business section of New York City within a distance of one mile of the Borough of Richmond and three miles of the Borough of Brooklyn.

Unusual Rights Apparently Granted by the United States Government.

The agreement entered into by the United States Government and the Passaic Valley Sewerage Commissioners contains the provision that the discharge of the sewage into the harbor at the locality chosen shall not reduce the available supply of dissolved oxygen in the water below the limit that would injuriously affect major fish life in the waters thereabouts. This provision apparently grants to the Passaic Valley Sewerage Commission the right to absorb all the margin of sewage capacity now remaining in the harbor waters, and opens the way to complications of a serious nature. The United States Government should not, and perhaps cannot legally grant to the Passaic Valley Sewerage Commissioners
4 the total or any definite proportion of the remaining capacity of the harbor waters to receive sewage.

Experimental Method of Discharge.

The method proposed for the discharge of the sewage beneath the surface of the harbor involves many constructional difficulties and uncertainties. It is not known that outlets of the form and character proposed can be constructed and maintained at the place designated. If, after the work on the tunnel shall have been partly or wholly completed, it be found that the system of outlets proposed cannot be built for the amount of money available, it is within the range of possibility that the plans now agreed upon would be changed to a simpler and less expensive form of construction to the material disadvantage of the method of disposal.

Extensive studies, including thousands of analyses, made by the Metroplitan Sewerage Commission concerning the quality of the water in Upper New York Bay, indicate that the discharge of sewage in the manner and in the quantities proposed by the Passaic Valley Commission would be attended by a heavy draft upon the capacity of the harbor for assimilating sewage. The quality of the water at the present time shows unmistakably the effects of the sewage now discharged into the harbor. The welfare of the cities situated upon the shores of the harbor requires that the water shall not be unnecessarily contaminated with the sewage of inland com-

munities. The burden of pollution should be increased only when strictly necessary, as where cities are situated on the water front and can provide no other method of disposal.

It is reasonably certain that a nuisance would appear at the outfall. The sewage from the Passaic Valley district cannot reasonably be expected to disappear without the production of local nuisance, including discoloration of the water, the appearance of greasy scum and offensive odors.

Availability of Other Methods of Disposal.

It is not the duty of the Metropolitan Sewerage Commission of New York to solve the problems confronting the Passaic Valley Sewerage Commissioners and state in detail what solution of this question should be adopted, but the plan proposed by the Passaic Valley Commission is not the only one available for disposing of the sewage.

It would be better, in the judgment of the Metropolitan Sewerage Commission, for the sewage of the Passaic Valley district to be purified upon the Newark meadows and the effluent discharged into Newark Bay. There is a large movement of tidal water in Newark Bay, and the saving in cost which would be effected if it were not necessary to construct an outfall tunnel beneath Newark Bay, the Bayonne Peninsula and New York Bay, with the expensive system of outlets proposed, would go far toward paying the cost of purifying the sewage to an extent which would make the discharge of the effluent into Newark Bay a safe procedure.

The suggestion that the Passaic Valley sewage be purified on the Newark meadows and discharged into Newark Bay should not be interpreted as an expression of opinion by the Metropolitan Sewerage Commission favorable to the Passaic Valley enterprise in any of its aspects. The collection of the sewage of that large territory to a central point for disposal is not the only way in which the sewage problems of the Passaic Valley can be solved. It might be more desirable to collect and dispose of the sewage of the different municipalities concerned on some other basis, as, for example, by a number of sewerage districts and at a number of sewage disposal plants. Favorable reports upon such projects have been made by eminent engineers at the instance of the City of Paterson in the Passaic Valley district.

The Secretary of War as Referee.

The agreement entered into between the United States Government and the Passaic Valley Commission stipulates that the sewage would produce no effects objectionable to the Secretary of War of the United States, either through interference with the navigable character of the channels or through the production of nuisance or conditions injurious to the public health. The agreement mentioned does not give adequate assurance to the people of New York

City and State that the Passaic Valley project will not become a public nuisance, and the method of enforcing the agreement is open to criticism.

The agreement is between the Passaic Valley Sewerage Commissioners and the United States through the Secretary of War. The War Department is not a legal health authority and has no responsibility of a sanitary nature toward the State of New
6 York or New York City. If the Passaic Valley sewage became a serious nuisance or menace to health to the people of New York City or State, it could not properly be objected to by the Secretary unless injury were done to the property of the United States Government. This property, including, principally, fortifications, is of insignificant character as compared with the interests of the City and State of New York.

Were the Passaic Valley sewage to produce a nuisance or substantial injury to the health of the cities situated upon the harbor of New York, there would be no way to stop the nuisance except by long and tedious litigation and the construction of extensive public works. Once the Passaic Valley sewer was built and in operation it would be impracticable to put a stop to the discharge of sewage through it, for the cities tributary to it would then have no other outlet for their offensive and dangerous wastes.

Action Recommended.

The present status of the Passaic Valley case is as follows: The State of New York brought suit against the Passaic Valley Sewerage Commission and State of New Jersey in the United States Supreme Court to prevent the execution of the Passaic Valley project. The United States Government requested and obtained permission to intervene in this suit and become a co-plaintiff in order to protect United States property in New York harbor against injurious consequences from the sewage. An agreement was thereafter entered into between the United States and the defendants whereby the latter agreed to purify the sewage to an extent and in a manner specified, on condition that the United States would withdraw from participation in the suit. This agreement has been ratified by the New Jersey Legislature and by the United States Attorney General. The suit still continues as between the State of New York and the defendants, but it is expected to be withdrawn unless continued for some unexpected reason.

The Metropolitan Sewerage Commission of New York recommends to your Honor that The City of New York take steps to assert its legal rights in the premises, and it is suggested that application be made to the United States Supreme Court for permission to intervene in the suit in order to become a co-plaintiff, to the end that public health and welfare in The City of New York shall be adequately protected.

A large amount of technical information bearing upon
7 the capacity of New York harbor to assimilate and otherwise dispose of the sewage of the Passaic Valley, and data concern-

ing the probability of a nuisance from this source are contained in the report of the Metropolitan Sewerage Commission dated April 30, 1910.

Respectfully submitted,

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK.
GEORGE A. SOPER, *President.*
JAMES H. FUERTES, *Secretary.*
H. DE B. PARSONS.
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

1 COMPLAINANT'S EXHIBIT No. 146. James D. Maher, Commissioner.

NEW YORK CITY, May 19, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Report on the Proposed Discharge of Sewage From the Bronx Valley Sewer.

Metropolitan Sewerage Commission of New York.

July 25, 1910.

Honorable William J. Gaynor, Mayor of The City of New York:

SIR: The object of this report is to recommend that The City of New York take action to prevent the discharge of crude sewage from the Bronx Valley sewer. The sewer is now in process of construction. It is intended to discharge its sewage into the Hudson River immediately outside of the New York City boundary. The plans are for works to accommodate the sewage of an ultimate population of 850,000 people.

The Metropolitan Sewerage Commission of New York brings the project of the Bronx Valley Sewer Commission officially to the attention of The City of New York and, after pointing out that the regular machinery of the State for the protection of public health has been made inoperative, recommends that The City of New York take such action through its legal department as may be necessary to safeguard the interests of its citizens in this matter. It is suggested that appropriate action lies in an application to the United States Supreme Court for permission to intervene in the suit of the United States vs. the State of New York and Bronx Valley Sewer Commission in the United States Supreme Court in order that The City of New York may become a co-plaintiff with the United States and have a voice in the proceedings.

Early Opposition to the Bronx Valley Sewer Project.

2 Permission for the construction and maintenance of the Bronx Valley sewer was given by special act of the New York Legislature approved May 26, 1905, and amended by subsequent acts.

Early opposition to the project was made by the Metropolitan Sewerage Commission of New York. In a letter dated September 18, 1906, the Metropolitan Sewerage Commission addressed a communication to the Chairman of the Bronx Valley Sewer Commission, pointing to the absence of provision in the Bronx Valley sewer plans for purifying the sewage before discharging it into the Hud-

son, showing the feasibility of purifying sewage, explaining the probable need of treating the Bronx Valley sewage, and recommending that provision be made in the plans for at least the minimum measure of treatment which future studies might show to be necessary. This communication led to conferences between the Bronx Valley Commission and the Metropolitan Commission, during which the subject was more fully discussed. The conferences were without result. The Metropolitan Commission had no authority to enforce its recommendations and it was impossible by other means to induce the Bronx Valley Sewer Commission to alter the plans.

At a hearing on the Bronx Valley project before the State Commissioner of Health and State Engineer and Surveyor in December, 1906, the Metropolitan Sewerage Commission registered official protest against the Bronx Valley sewer project on account of its failure to provide purification for the sewage before discharging it into the Hudson River. Under the general laws of New York State, all plans for sewerage and sewage disposal must receive the approval of the Health Commissioner and State Engineer and Surveyor before they can be carried out.

At the hearing just mentioned, protests were also made and petitions filed by organizations representing the entire trade and commerce of The City of New York. The civic bodies included the Chamber of Commerce of the State of New York, the New York Produce Exchange, the Maritime Association of the Port of New York, the Merchant's Association of New York, the New York Board of Trade and Transportation, the West End Association and the American Steamship Association.

These protests were without avail, for the State Engineer and the State Commission of Health had apparently been deprived of their usual functions with respect to this sewerage project. It was presently declared by the Attorney General of the State that the special act of Legislature under which the Bronx Valley Sewer Commission existed placed the operations of that commission outside the jurisdiction of the State Commissioner of Health and the State Engineer and Surveyor. The Legislature had apparently
3 given permission to the Bronx Valley Commission to discharge its sewage into the Hudson River without regard to consequences.

At the present time the State of New York is being compelled to defend the construction of the Bronx Valley sewer, having been placed in this position by the United States Government. A suit for a permanent injunction to prevent the construction and operation of the sewer is pending in the United States Supreme Court between the United States on the one side and the State of New York and the Bronx Valley Sewer Commission on the other. Pending trial of this suit, the work of constructing the sewer is being pushed rapidly. Because of the rapidity of construction and delays attending the suit, it is now proposed by the United States Department of Justice to apply to the United States Supreme Court for an injunction which will stop the work until the trial determines whether a permanent injunction shall be issued.

The suit brought by the United States against the State of New York and the Bronx Valley Sewer Commission is based on the injury which the Bronx Valley sewer is expected to do to property of the United States situated in New York Harbor, to the health of soldiers and sailors, and to the navigable channels which are the particular concern of the Government of the United States. The bill of complaint is a concise and conservative statement of the magnitude of the port, its importance as a commercial centre, the nature and cost of the harbor channels and other facts of interest in the case. A number of expert opinions with respect to the consequences to be apprehended are quoted from reports of United States Army officers of high rank and recognized sanitary experience. It is expected that arguments in the case will be heard in the autumn of 1910.

Necessity for Action by The City of New York.

Although likely to be seriously affected by the outcome of the case, The City of New York has, up to the present, taken no part in the legal proceedings against the Bronx Valley sewer project. The City has not been officially apprised of the situation or advised to take any legal steps in the matter. The time has now arrived when appropriate action should be taken. Information has come into the possession of the City to show the consequences which may reasonably be expected if the Bronx Valley sewage is discharged in the manner and quantity proposed. This information, collected by the Metropolitan Sewerage Commission is believed to be sufficient to make effective protest in a court of law.

4

The objections which are here made against the Bronx Valley sewer are similar to those already urged against the Passaic Valley sewer. The opinion of the Metropolitan Sewerage Commission concerning the Passaic Valley project has already been formulated and officially brought to the attention of the Mayor of The City of New York with the recommendation that the City become a co-plaintiff with the State of New York in a suit now pending in the Supreme Court at Washington, between the State of New York on the one side and the Passaic Valley Sewerage Commission and the State of New Jersey on the other, to prevent the discharge of sewage in accordance with the plans of the Passaic Valley Sewerage Commissioners.

The Bronx Valley and Passaic Valley projects belong to a class of drainage schemes to which the Metropolitan Sewerage Commission and its predecessor, the New York Bay Pollution Commission, have registered repeated protests. These protests have been made without respect to the governmental boundaries in which the sewers are built or within which they produce their worst effects. The chief ground for objection lies in the fact that such sewers are intended to carry to New York Harbor, already too heavily polluted with the sewage from the dense populations crowded upon its shores, large quantities of sewage from inland communities, which can provide other means of dealing with this waste.

Essential Facts Concerning the Bronx Valley Sewer.

The Bronx Valley project is of great magnitude. The total area in the assessment district is 35 square miles. The present population is about 30,000 and the ultimate population expected is 850,000. The daily discharge of sewage provided for at the commencement of operation is 3,000,000 gallons, and the ultimate discharge 90,600,000 gallons. The cost of the works, up to the time of opening, including expenses for land and incidentals, as estimated at $2,256,000. The sewer will begin at the northern boundary of White Plains and pass through Scarsdale, Tuckahoe, Bronxdale and part of Yonkers and Mount Vernon. The diameter of the sewer at its upper end is to be 3 feet 4 inches and at its lower end 8 feet 6 inches. The sewer is intended to carry only household drainage. Storm water is to be excluded. The total length of the sewer is to be 14 miles. The outlet is to be about 300 feet north of the point where the northerly line of the City of New York intersects the Hudson river.

The outlet, as planned, is to consist of two lines of 48-inch cast iron pipe, extending to a point in the river 500 feet from the shore and 40 feet below the surface of the water.

The theory upon which the sewage is to be emptied into the river is that the sewage will be mingled with and dispersed by the water of the river with such speed and completeness as to disappear. Disposal beneath the surface in the manner proposed is an improvement upon discharge at the surface, but the Metropolitan Sewerage Commission is of opinion that the sewage would not satisfactorily disappear under the conditions stated.

Probably the best example in the United States of a large quantity of sewage discharged beneath the surface of tidal water is afforded at Peddock's Island in Boston harbor. Here 40,000,000 gallons of sewage per day is discharged through a single outlet located 30 feet beneath the surface. Contrary to the theory of immediate disappearance, the sewage at Peddock's Island rises at once and make its appearance at the surface in a dense, discolored and offensive stream. The solid matters of the sewage rise with the liquid portion, particles of paper, fruit peelings and excrement being easily distinguishable. Traces of the sewage are sometimes visible for more than a mile.

Aside from the local nuisance which would be produced, the Bronx Valley sewage would add a considerable burden of impurities to the water which would have to be flushed away or assimilated by the water. As will be more fully explained, the flushing action of the harbor is incomplete and irregular. Most of the sewage which is discharged into it must be absorbed. The disappearance of the sewage depends upon the liquefaction and assimilation of the organic constituents. These processes are carried on largely through the activities of low forms of life natural to the water, such as bacteria and infusoriæ. When the quantity of sewage is so great as to overcharge the capacity of these agencies, disagreeable consequences

follow, notably discoloration of the water, evolution of foul odors and deposition of solid matter.

In New York harbor, deposits often occur near sewer outlets, and putrefactive changes, with the escape of offensive gases, take place. When the Bronx Valley sewer is first put in operation, the solid matter in the sewage will reach 1,400 tons per annum. This amount will be increased to at least 36,000 tons when the capacity of
6 the sewer is reached. In addition to this solid matter, large quantities of decomposing organic matter will be discharged in liquid form.

Present Sanitary Condition of New York Harbor.

The present condition of New York Harbor has been ascertained by studies, extending over several years, by the Metropolitan Sewerage Commission and the New York Bay Pollution Commission. Thousands of bacteriological and chemical analyses have been made of the waters at all depths, at all seasons and at practically all points. Studies of the tidal phenomena have been made and the intermixtures of ocean water and water brought down by the Hudson and other rivers have been determined daily for one year. Some of this work has been done in co-operation with the United States Coast and Geodetic Survey, experts of that branch of the government having, at the request of the Metropolitan Sewerage Commission, made an exhaustive research and compilation of all existing data in their possession relating to the direction of currents and the quantities of water flowing in and out of New York Harbor.

From these studies, the Metropolitan Sewerage Commission has deduced many facts with relation to the capacity of New York Harbor for sewage, the most important of which is that the harbor is far less capable of disposing of sewage in an inoffensive and sanitary manner than is commonly supposed.

Contrary to a belief now popularly held and formerly supported by apparently strong technical authority, the principal result of the movement of sea water in New York Harbor is to cause the sewage which is discharged into it to oscil-ate back and forth near the sewer outfalls. The harbor is not effectively flushed out by the tides. Aside from the water which is brought down by the Hudson and other rivers, there is practically no more water flowing seaward than landward. In certain parts of the harbor stagnation occurs. The condition of the waters in the open main channels makes it plain that sewage must be kept out of the harbor as far as it is practicable to keep it out.

The digestive capacity of the harbor for sewage has a limit. If this limit is passed, the water will become black, foul-smelling and putrid. Obnoxious gases will arise from it. In parts of New York Harbor such conditions as these now exist and are becoming more extensive as time passes. At present they are located for the most part in closely built-up factory sections, but their injurious
7 effects extend beyond local limits, and contribute to the polluted condition of the whole bay.

It has been found that practically the whole of upper New York Bay and the lower Hudson are underlaid by an accumulation of foul-smelling, black ooze in which fragments of sewage origin are readily discoverable. These deposits are of considerable thickness, sewage matters having been brought up from a depth of ten feet below the surface of the mud.

As might be expected under the circumstances, the number of bacteria in the harbor water is excessive. While clean sea water generally contains not more than a few hundred bacteria per cubic centimeter, the polluted waters of New York Harbor contain thousands. The average of a large number of analyses shows that the number of bacteria in the lower bay is about 1,300 per cubic centimeter of water; in the upper bay about 14,500; in the Hudson River, opposite Manhattan, about 6,600; in the vicinity of the proposed outlet of the Bronx Valley sewer the average number of bacteria per cubic centimeter has been found to be about 5,300. Intestinal bacteria are to be found everywhere. The water north of the Narrows is unsuitable for the cultivation of shellfish and dangerous to bathe in. The collection of driftwood for fuel is attended by considerable risk of disease.

The condition of the water with respect to its capacity for absorbing sewage without producing great offense is well indicated by the quantity of dissolved oxygen which the water contains. Sewage draws upon the oxygen supply, and when the oxygen in the water is exhausted the organic matter in the water putrefies. While clean sea water and uncontaminated river water normally contain 100 per cent of oxygen, the water of upper New York Bay contains but 67 per cent.; the Hudson River, opposite Manhattan, 72 per cent.; and the water near the proposed outlet of the Bronx Valley sewer, 83 per cent. of the quantity of oxygen which it should have.

The movement of the main tidal currents which oscillate backward and forward in New York Harbor has been well shown by floating objects which have been set adrift by the Metropolitan Sewerage Commission. There have been over seventy experiments of this kind. Some of those floats have been followed day and night by means of boats. One such float was started at the beginning of an outflowing tide on November 10, 1909, at 8.25 A. M., at Spuyten Duyvil, about three miles nearer the ocean than the proposed outlet of the Bronx Valley sewer. It flowed up and down in the Hudson, back and forth in the Upper Bay and to and fro in the Narrows until, on November 12, at 2.20 A. M., it had reached a point opposite Coney Island in the Lower Bay. Three times the direction had been reversed by the currents. For two days the float had drifted about the harbor. It had covered a total distance of 63¼ miles, while the direct distance from start to finish was 24½ miles. The conditions on this occasion were by no means unusual. The float was started at a stage of tide which was distinctly favorable to a prompt and direct passage to sea.

Summary of Objections to the Bronx Valley Sewer Project.

The objections which careful inquiry has shown to exist with respect to the Bronx Valley project are numerous and cannot all be stated here. Perusal of the foregoing pages will show their general nature. For convenience, a few of the main considerations which are opposed to the discharge of crude sewage from the Bronx Valley sewer follow:

1. The project would increase the pollution of the harbor as a whole and add materially to the pollution of that port of it where the sewer would discharge.

2. The proposed outlet is so near the New York City line that property in the city would be as surely affected as if the sewer was made to discharge within the city limits. Being outside of its boundaries, the City of New York would have no jurisdiction over the outlet.

3. Land in the neighborhood of the outlet is occupied by high-class residences and by large philanthropic institutions, chiefly homes for children. It is estimated that one thousand children reside in the neighborhood of the proposed outlet.

4. At the present time, sewage from the City of Yonkers, discharging about a mile above the proposed outlet of the Bronx Valley sewer, can sometimes be seen flowing down the Hudson in a stream for several miles. The sewage from the Bronx Valley sewer would increase this sewage stream and add to the consequent dangers and annoyances.

5. Objections to the Bronx Valley project exist in the fact that it is opposed to the policy of protecting the harbor which has been officially formulated by the State and City of New York through the Metropolitan Sewerage Commission.

6. In all the ways in which the pollution of the Hudson
9 River and New York Harbor may affect public health and comfort, the discharge of sewage from the Bronx Valley sewer would be an aggravating and growing factor.

7. Objection against the discharge of crude sewage from the Bronx Valley sewer exists for the reason that it would benefit one section of the metropolitan district at the expense of others. It should be a subject of mutual effort to keep the harbor clean as it is a matter of importance to all the people of the metropolitan district, in a part of which the Bronx Valley sewer is located. The City of New York, the chief offender against this policy as matters have stood in the past, is taking active steps to deal with its sewage in a sanitary manner.

8. The first step toward the protection of the harbor was taken by The City of New York when the Metropolitan Sewerage Commission was created to make an official study of the conditions of sewage disposal, and formulate a general plan or policy of conservancy for the metropolitan district of New York and New Jersey without respect to state or municipal lines. This investigation, made with strict impartiality, and involving the study of conditions outside as

well as inside of the limits of New York City, was paid for by The City of New York for the common good.

A second step taken by New York City for the protection of the harbor was made when the Legislature, at the request of the City, extended the life of the Metropolitan Sewerage Commission from May 1, 1910, to May 1, 1913, in order for it to make plans and estimates for the works necessary to protect the harbor as far as practicable from the sewage of New York City.

9. Objection to the Bronx Valley project exists for the reason that the evil consequences which will result will not be occasional or temporary, but continuous and increasing. The quantity of sewage will become greater as time proceeds, but the quantity of water into which it will be discharged will remain always the same. It is well within the range of probability that the estimates of future population of the Bronx Valley sewer district are too low, and that the remarkable growth of population now taking place in all parts of the suburbs of New York will make necessary a parallel sewer through the Bronx Valley, which will greatly increase the expected quantity of sewage discharged at the proposed outlet.

10. Objection to the Bronx Valley project arises from the fact that if no means for purifying the sewage are now provided, or land procured for the same, such works may prove impracticable to construct or locate in future without incurring greater expense than the residents of the Bronx Valley district are able to meet.

11. The Bronx Valley Commission cannot lay claim to unexpected insistence upon the purification of its sewage. They were notified by the Metropolitan Sewerage Commission in 1906 that they should make provision for such purification works as might eventually be found necessary.

12. Objection to the Bronx Valley project lies in the fact that special legislation took from the State Department of Health the jurisdiction which the general laws of the State intended that department to exercise over all questions of sewerage and sewage disposal. The State Department has, within recent years, made commendable efforts to protect the purity of the rivers of the State, yet the discharge of the Bronx Valley sewer, intended ultimately to dispose of a larger quantity of sewage than is produced by some of the cities of the State, is beyond the control of any sanitary authority.

Respectfully submitted.

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK.
GEORGE A. SOPER, *President.*
JAMES H. FUERTES, *Secretary.*
H. DE B. PARSONS.
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

a COMPLAINANTS' EXHIBIT No. 147. James D. Maher, Commissioner.

NEW YORK CITY, May 19, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York's Sewage.

I.

Study of the Collection of the Sewage of New York City to a Central Point for Disposal.*

Metropolitan Sewerage Commission of New York: George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.

SEPTEMBER, 1911.

1 Study as to the Feasibility and Desirability of Collecting the Sewage of New York City at a Central Point for Disposal.

It has occasionally been suggested by engineers and others who have recognized the need of stopping the pollution of New York harbor that all the sewage be collected into one system of main drainage and pumped out to sea.

The benefits which would accrue from this solution of the sewage problem are so apparent that the Metropolitan Sewerage Commission of New York has given serious attention to the practicability of such a project. The following report is intended to describe the essential engineering features of the four forms of this general project which have seemed to the Sewerage Commission most promising. It would be within the range of engineering ability to carry out any of them, but the Commission considers that the benefits which would be secured would not be sufficient to justify their cost.

The point suitable for the outlet of a sea-going tunnel would depend upon the quantity of sewage to be discharged and the uses to which the neighboring shore might be put. The larger the quantity of sewage to be disposed of, the farther the outlet should be from land. Other considerations affecting tthe location are the condition of the sewage with respect to the solid matter contained, the presence or absence of putrefaction, the action of the tidal currents and the uniformity or intermittency of discharge.

* This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

The territory which might appropriately be included in a drainage system whose object was disposal of the sewage at sea could apparently include the metropolitan district of New Jersey as well as New York. No insuperable reason is apparent why the two states should not unite in the construction of a single system of main drainage. The quantity of sewage to be disposed of would therefore be the quantity which would be produced in New York and New Jersey within about twenty miles of the New York City Hall.

Either Long Island Sound or the Atlantic Ocean might seem to afford a suitable site for the discharge of the sewage. There is, however, no point in Long Island Sound, within reasonable distance, where the waters are sufficiently open and where the outlet could be sufficiently far from inhabited shores to make the discharge of such a large quantity of sewage free from objectionable consequences. The extensive use of the bottom of Long Island Sound for the cultivation of oysters also makes these waters unsuitable. The Atlantic Ocean would be the only place which would be suitable for the discharge of the sewage. The condition of the sewage would neither
2 favor nor hinder its prompt disappearance. The largest solid materials would be removed by screens for the protection of the pumps which would be required to force the sewage to the outlet, and some solid matter would be broken up by the passage of the sewage through the sewers, so that the matters left in suspension would be in finely divided condition.

The length of the sewers would be so great that the sewage would be in a state of decomposition by the time it reached the outlet and would therefore be more offensive than fresh sewage. In consequence of this fact, the water in the vicinity of the outlet would be more offensively polluted than it would be were the sewage to be discharged in fresh condition. The distance of the outlet from the shore should be correspondingly greater.

Just how far the outlet should be from shore is not susceptible of exact determination. From six to ten miles seems not too great a distance in view of the re-entrant angle formed by the coast line and the large number of residences and summer resorts along the beaches.

Continuous Discharge at Sea.

Experience shows that the sewage would mingle slowly with the sea water. It would, in all probability, rise in a column from the outlet at the bottom and flow away at the top, its destination as sewage being determined partly by the tidal currents, partly by the force and direction of the wind and partly by the intermixing action of the waves.

Studies have been made by the Sewerage Commission of the tidal currents and effects of wind at sea near the location which might be selected for the outlet. Opportunity to investigate this subject was afforded in the year 1906, when the garbage of New York City was being dumped at sea during a temporary suspension of the reduction plant at Barren Island, where the garbage is customarily dealt with. The point selected for sea-dumping of garbage was seventeen miles

southeast of the fairway buoy at the entrance of Gedney Channel. This point was about fifteen miles from the New Jersey and New York shores. Inspectors employed by the Sewerage Commission examined the beaches over a period of some weeks and investigators for the Commission cruised about upon the waters to note the presence and distribution of the refuse.

It was found that the garbage remained in floes or fields for long periods of time. It traveled at rates approximating a maximum of two miles an hour under what appeared to be normal conditions of wind and tide. There was a distinct fouling of the shore lines over a distance of fifty miles from New York along Long Island and seventy-five miles along the New Jersey coast. Some 3 of the floating material returned to New York and was found moving into the inner harbor through the Narrows.*

Wind undoubtedly had an effect upon this floating refuse, but wind would also have an effect upon the movement of sewage. Wind moves the whole surface of the water upon which it blows, as has frequently been observed by the Commission in studying the behavior of sewage in Upper New York Bay.

An examination of the depths of water along the New York and New Jersey coast lines, as recorded upon the official charts of the United States Coast and Geodetic Survey,† shows that there is no point available at a distance of ten miles from shore where a sea-going tunnel could well be built. As the bottom for the most part is sandy, a tunnel would have to be built by compressed air. The depths required would exceed 120 feet, which is about the limit at which it is practicable to use the process. There would be serious difficulties, although not insuperable ones, in the construction of any long tunnel to sea.

From considerations of cost, excessive depth and magnitude of construction, the plan of carrying all the sewage of New York and New Jersey to sea is considered by the Sewerage Commission to be impracticable.

If New Jersey were left out of the project and New York undertook to discharge its own sewage at sea, the engineering problems would be somewhat simplified, but they would not be reduced to the range of practicability. The quantity of sewage would be approximately four-fifths of that of the entire territory. The tunnels could be fewer in number and the distance of the outlets from the shore less, but the general nature of the works and the difficulties of construction would be similar. The construction of the sea-going tunnel and its outlet would still be a great obstacle.

Discharge at Sea on Outgoing Tidal Currents.

The length of the sea-going tunnel could be materially shortened if the sewage could be stored temporarily on shore and discharged only on outgoing tidal currents. In this case the full benefit of the

* Report Metropolitan Sewerage Commission of New York, April 30, 1910, pp. 380-388.

† Chart No. 120, United States Coast and Geodetic Survey.

transporting power of the water as it moved from the land could be utilized to carry the sewage as far away as possible.

This modification or any other departure from the plan of a continuous sea-going sewage discharge has seemed to make it necessary to exclude New Jersey sewage from consideration. It has
4 seemed unwise to the Sewerage Commission to suppose that the people of New York would consent to receive New Jersey sewage for disposal on New York soil, or vice versa.

Considering that New York's sewage was alone to be disposed of and that the discharge at sea was to take place only on outgoing currents, it is considered by the Sewerage Commission that the outlet could be located within about five miles from shore. A point suitable for departure from shore would be in the vicinity of Rockaway Point, with storage basins situated in the neighborhood of Barren Island. Because of the necessity for discharging intermittently, the tunnel capacity would have to be larger than would be required for continuous discharge.

It has been estimated that the quantity of sewage to be disposed of in 1940 would be 1,330,000,000 gallons per day. (See Appendix A.) This would be discharged in two periods of four hours each. The storage basins and pumping station would have to cover an area of 125 acres and have a depth of 20 feet to store the sewage during the periods when suitable seaward-moving currents were not flowing. There could be 4 tunnels of 18 feet diameter each. The tunnels could ran parallel to one another until near their outer ends, when they would separate to some extent. (See Appendix B.)

To collect the sewage to the vicinty of Rockaway Point for disposal at sea, there would be need of a system of collecting and intercepting sewers running to all parts of New York City. Staten Island would be connected by a tunnel beneath the Upper Bay. Manhattan would be provided with intercepting sewers running around the water front. The sewage would pass under the East River to large collecting sewers which would thence flow in the direction of the storage reservoirs near Barren Island. The sewage of Brooklyn would be collected by interceptors and collectors. A branch would run to The Bronx and another to a central point to take in the sewage of Northern Queens from the vicinity of Flushing. The sewers of this main drainage system would be of large magnitude, some of them approaching the dimensions of rapid transit subways.

To a large extent the present sewerage systems which receive the sewage directly from the houses would be utilized. The object of the main drainage works would be to collect the sewage from these sewerage systems and carry it to the disposal works.

As far as estimates have been made, it appears that the plan of collecting the sewage of New York to a central point and discharging it at sea on outgoing currents should not be recommended because of its cost. It is believed that the works would cost not less than $140,600,000. (See Appendix B.) It is possible that
5 such works may be needed in the remote future, but for the

present their large cost does not seem to be justified by the benefits which they would confer.

Application of the Sewage to Farm Land.

If the sewage of New York was collected to a central point for disposal, it could be dealt with in other ways than by discharge at sea. The sewage could be utilized by employing it for agricultural purposes or it could be purified to such a degree that the effluent would be non-putrescible and harmless. The Commission does not consider that either of these two latter plans is necessary or desirable, but it may be well to refer to some facts which should be taken into consideration in discussing the feasibility of these two procedures. Many persons have favored disposal on land, assuming that the sewage could in this way be turned to profitable use instead of being wasted. Intensive purification also has its advocates. The remarkable progress which has been made in employing bacteria and other agencies to carry on the purification of water and sewage under conditions which could be controlled lends considerable interest to this subject.

Considering first the possibility of applying the sewage to farm land, it is necessary to determine where the sewage of New York could be carried for disposal and how much land would be needed.

If the sewage of New York was to be disposed of on soil within the State, it would have to be taken to Long Island, for there is no other land within reach which has a suitable elevation and is of suitable quality. Long Island is low, flat, sandy and accessible.

To carry the sewage to Long Island for disposal on land, it should be collected first to a central point and from there pumped to the irrigation fields. A suitable central point would be in the vicinity of Jamaica. A system of main drainage including collectors and interceptors to carry the sewage which had been gathered by the lateral sewerage systems of the Metropolis would lead to a main pumping station. From the pumping station conduits would be needed to carry the sewage to the disposal fields. It would probably be economical to construct three such conduits with a diameter of 19 feet each. The fields might begin in the vicinity of Amityville, a distance of about thirty miles from the New York City Hall. Any point nearer would be unsuitable for the disposal of a large quantity of sewage because of the numerous villages, towns and other suburban settlements which exist.

About 175 square miles of land would be needed on the assumption that 12,000 gallons of sewage could be utilized per acre
6 per 24 hours. This is the highest rate which should be allowed. A tract of suitable elevation and of proper quality of soil can be found running from Amityville to Quogue, a distance of about fifty miles.

From an engineering standpoint, the idea of applying sewage to the sandy soil of Long Island is feasible. It is estimated that the cost of the works necessary would be about $153,000,000. (See

Appendix C.) The purchase of the land would add greatly to the above cost.

There are apparently insuperable obstacles to the successful carrying out of this project. Aside from the great cost of works and of land, it would be necessary to eliminate villages and towns and to acquire the right to the property of many large estates and public institutions or provide a larger total area than that mentioned. More important still, a part of the water supply of New York might be seriously interfered with. A large part of the drinking water for Brooklyn is obtained from wells on the south side of Long Island, and it seems improbable, even if no injurious consequences followed to the water, that public opinion would permit the sewage of the Metropolis to be disposed of on the same land from beneath which the water was derived.

Passing now from a consideration of the feasibility of disposing of the sewage upon farm land to the possibility of dealing with it by intensive purification, we may take up the last problem of handling the sewage after collecting it to one central point.

Intensive Purification of the Sewage.

For disposal by intensive purification, the sewage would be brought to a central point by a system of main drainage, including such collectors and interceptors as have already been sufficiently described.

The place to which the sewage would be brought could conveniently be the vicinty of Jamaica Bay.

The process of purification would presumably be settlement for the removal of the larger solid impurities and biological treatment for the oxidation of the dissolved organic matters. If the effluent, after purification, was to be discharged into the waters of Jamaica Bay or near the shore of the ocean, it could be disinfected so that it would practically, if not completely, be free from disease germs.

It seems unnecessary to describe the details of the purification which should be employed. It is well within the range of engineering ability to construct the works and to produce an effluent of any required degree of purity. Estimates have been made of the cost of intensive treatment, assuming that disinfection would not
7 be necessary, but that settlement followed by oxidation in sprinkling filters would be the most desirable process. The collection and treatment works would cost approximately $141,000,000. (See Appendix D.)

This sum, in the opinion of the Sewerage Commission, is a very large price to pay for the results which would be accomplished. It is, in the Commission's view, unnecessary at the present time to construct such a complete system of main drainage as would be required in order to collect all the sewage of the Metropolis to one central point.

Desirability of Subdividing the Territory for Sewage Disposal.

The plan of collecting all the sewage to a central point for disposal is, fortunately, not the only way to protect the harbor against

sewage pollution. It is the opinion of this Commission that works of less magnitude and cost can be constructed to answer all the requirements of the harbor, as a whole, and with special regard to the needs of certain localities.

Fundamental to the design of such large sewers, treatment works and outlets as are required, is a division of the metropolitan territory of New York into districts. The boundaries of these districts should coincide approximately with the principal natural drainage areas of the land. The sewage should be collected and treated in each of these districts in such ways as to afford all the relief needed for the near future, and their design should be such as to fit into a more comprehensive plan, if more protection is needed at a distant time.

The division of the metropolitan territory into districts, the manner and extent of the protection proposed for the waters of the harbor, and the cost of the drainage and disposal works will be the subjects of special reports to be submitted by this Commission as rapidly as the progress of the investigations permits.

Review and Conclusions.

Reviewing the various subjects dealt with in this report and combining the main facts and opinions for convenience of review, the following subjects seem to this Commission to be of special interest:

1. Although not necessary, it is within the range of engineering ability to collect all the sewage of the metropolitan district of New York and New Jersey to a central point for disposal.

2. The sewage of New Jersey, as well as that of New York, should be collected to a central point only in case the sewage is to be discharged at sea continuously and not exposed upon or above the surface of the ground.

8 3. It would not be desirable, from engineering considerations and on account of the cost, to discharge continuously all the sewage of the New York and New Jersey metropolitan district at sea, nor the sewage of New York at sea during all stages of tide.

4. The sewage of New York could be intermittently discharged at sea through tunnels, by employing storage basins and allowing the sewage to flow away on outgoing currents. The cost seems to make this plan prohibitive.

5. The sewage of New York could be carried to Long Island and disposed of on land, so far as engineering considerations are concerned, but the cost would not be justified.

6. The sewage of New York could be purified at one point so as to be inoffensive and without serious chance of harm to health. The works would cost what seems to be an excessively large amount of money.

7. The cost of collecting the sewage to one point and disposing of it intensively would be smaller than the cost of applying the sewage to land, but it would still be so great as to make the project appear to be inadvisable.

8. At some remote time, it may be necessary to collect all the sewage of New York to a central point for treatment or discharge at sea. This fact should be kept in mind in laying out such systems of main drainage and treatment as may be necessary for the present and near future.

9. The plan of collecting all the sewage to a central point seems to be unnecessary for the reason that other remedies, costing less money and involving fewer engineering and sanitary difficulties, appear to be more suitable. These remedies lie in dividing the City of New York into districts, determined chiefly by natural drainage areas, and providing main sewers and proper methods of disposal for each. The boundaries of these districts and the way in which this Commission proposes to deal with them will be the subject of future reports.

METROPOLITAN SEWERAGE COMMISSION.
GEORGE A. SOPER.
JAMES H. FUERTES.
H. DE B. PARSONS.
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

9

APPENDIX A.

Revised Estimates of Population and Sewage Flow.

The following revised estimates of population and sewage flow of New York City in 1940 were made after the results of the United States census enumeration of 1910 became available. This was subsequent to the publication of the report of the Metropolitan Sewerage Commission, dated April 30, 1910.

Population.

The estimated population of New York City in 1940, as given in the report of the Metropolitan Sewerage Commission, dated April 30, 1910, on page 144, was 8,666,100. This result was reached after a careful study of population data available at the time. From curves drawn to show the probable future growth of population in each of the boroughs from which this total was made up, the estimated population of the City in 1910 was found to be 4,600,000. The U. S. census of 1910 gave the population of New York City as 4,766,883, indicating that the actual rate of growth in the city had been somewhat greater than that assumed in the estimates made by the Commission.

In view of this fact, and after full consideration of the subject, it was decided to take 9,000,000 instead of the earlier estimate of 8,666,100 as the approximate population of New York City in 1940.

In Table 1 of this appendix will be found summarized by boroughs, the estimate of population of New York City in 1910, as made by

the Commission prior to April 30, 1910; the population as determined by the U. S. census in 1910; the estimated population in 1940 as made by the Commission prior to April 30, 1910, and the revised estimates of population in 1940, as made subsequently.

Volume of Sewage Flow.

The estimated volume of sewage flow of New York City in 1940, as given in the report of the Commission, page 146, was 1,580,000,000 gallons per 24 hours. Information obtained subsequent to the publication of the report made it seem advisable to reconsider this estimate and, as a result, new estimates were made. These gave 1,330,000,000 gallons per 24 hours as the total estimated volume of sewage flow of New York City in 1940.

The following facts led to the making of the new estimate:

1. Definite knowledge as to the population in New York City in 1910, the returns of the U. S. census of 1910 having become available.

2. More definite information as to the probable total water consumption and water consumption per capita in New York City in 1910, figures of the water consumption in 1909 having become available, from which, with definite knowledge as to population, a reasonably close estimate could be made of the probable water consumption in the City in 1910.

3. Figures from the Board of Water Supply giving their estimate of the future population and total water consumption in each of the boroughs of New York City in 1940.

In Tables 2, 3, 4 and 5 of this appendix are given the estimate of the volume of sewage flow in New York City in 1940 made by the Commission prior to April 30, 1910, the revised estimate made subsequent to April 30, 1910, the estimated water consumption in New York City in 1910 and the estimate of the population and water consumption in New York City in 1940 made by the Board of Water Supply.

Table 1.

Estimated Population in New York City in 1910 and 1940.

Borough.	Estimated population in 1910.	Population by U. S. Census of 1910.	Estimates of population in 1940 by Met. Sew. Com.	
	M. S. C. Report of 1910, p. 138.		M. S. C. Report of 1910, p. 144	As revised Oct. 13, 1910.
Manhattan	2,360,000	2,331,542	4,143,200	3,600,000
The Bronx	354,000	430,980	979,400	1,280,000
Brooklyn	1,740,000	1,634,351	2,730,100	3,200,000
Queens	256,500	284,041	682,400	870,000
Richmond	83,500	85,969	131,000	130,000
Total	4,900,000	4,766,883	8,666,100	9,000,000

TABLE 2.

Estimated Volume of Sewage Flow in New York City in 1940 as Given in the Report of the Metropolitan Sewerage Commission Dated April 30, 1910.

Borough.	Estimated population in 1940.	Estimated volume of sewage flow in 1940.	Corresponding volume of sewage flow in gals. per capita per 24 hours.
	M. S. C. Report of 1910, page 144.	M. S. C. Report of 1910, page 148. Mdg.*	
Manhattan	4,143,200	650	157
The Bronx	979,000	195	199
Brooklyn	2,730,100	560	205
Queens	682,400	145	213
Richmond	131,400	30	228
Total	8,666,100	1,580	182

* Million gallons per day of 24 hours.

TABLE 3.

Revised Estimate of Volume of Sewage Flow in New York City in 1940 as Made by the Metropolitan Sewerage Commission Submitted to April 30, 1940.

Borough.	Estimated population in 1940	Estimated volume of sewage flow in 1940	Corresponding volume of sewage flow in gals. per capita per 24 hours.
	As revised Oct. 13 1940	Revised. Mgd.*	
Manhattan	3,600,000	583	162
The Bronx	1,200,000	159	132
Brooklyn	3,200,000	426	133
Queens	870,000	138	159
Richmond	130,000	24	185
Total	9,000,000	1,330	148

* Million gallons per day of 24 hours.

TABLE 4.

Estimated Water Consumption in New York City in 1910.

Borough.	Population by U. S. Census of 1910.	Rate of increase in population per year.	Total estimated water consumption.		Estimated water consumption in 1910.
			Mgd.*		
		Per cent.	1909.§	1910.†	Gals. per capita per 24 hours.
Manhattan	2,331,542	2.6	297	305	131
The Bronx	430,980	11.49	36	40	93
Brooklyn	1,634,351	4.01	154	160	98
Queens	284,041	8.56	27	29	102
Richmond	85,969	2.83	8	8	93
Total	4,766,883	3.87	522	542	114

* Million gallons per day of 24 hours.
† Derived from figures for the year 1909, assuming that the consumption of water increased at the same rate as the population.
§ Estimate of W. W. Brush, Deputy Chief Engineer, Department of Water Supply, Gas and Electricity, New York City.

TABLE 5.

Estimate of Population and Water Consumption in New York City in 1940, *Made by the Board of Water Supply.*

Borough.	Estimated population in 1940 §	Total estimated water consumption in 1940.§	Estimated water consumption in 1940.
		Mgd.*	Guls. per capita per 24 hours.
Manhattan	3,000,000	480	160
The Bronx	1,316,000	165	125
Brooklyn	3,823,000	470	123
Queens	924,000	116	126
Richmond	195,000	24	123
Total	9,258,000	1,255	136

* Million gallons per day of 24 hours.
§ Figures furnished by A. D. Flinn, Department Engineer, Board of Water Supply, New York City.

12 APPENDIX B.

Discharge of New York's Sewage at Sea.

This project has for its aim the disposal at sea of all the sewage from New York City. The sewage would be collected by means of long, intercepting sewers all leading to one central point near Rockaway Inlet at the ocean entrance to New York harbor, where a pumping station and large retaining reservoirs would be located.

This project involves the discharge of the sewage intermittently at sea at a point about five miles southeast of Rockaway Point and during the first four hours of each outgoing tide. The sewage would be pumped continuously to the retaining reservoirs.

The estimated cost of the above project is $140,600,000. It would care for 1,330 million gallons of sewage per 24 hours. It is estimated that there will be a dry weather flow of sewage from a population of 9,000,000 persons in the year 1940.

The estimate of cost given above is, at the best, but a very rough approximation and should be considered only as such.

Sewers.

In order to carry the sewage to Barren Island, five main sewers would be built, as follows:

Richmond-Brooklyn Line.
Manhattan-Brooklyn Line (West).
Manhattan-Brooklyn Line (East).
Bronx-Queens-Brooklyn Line.
Queens-Brooklyn Line.

Pumping Stations.

In addition to a main pumping station near Rockaway Inlet, pumping stations would be required at one or more points on each of the five main sewers or their branches.

It is assumed that the maximum capacity of the pumps in each station would be 50% in excess of what may be termed the average capacity; in addition to this a reserve capacity has been provided.

Storage Reservoirs.

It is assumed that the sewage would be stored during a period of 8 hours and that the volume so stored would be discharged at
13 sea during the subsequent 4 hours, together with the sewage reaching the central pumping station during this latter period.

It is assumed that 50% of the average daily flow of 1,330 million gallons might reach the central station during a period of 8 hours. To store this volume of sewage, reservoirs having a capacity of 665 million gallons would be required.

With a depth of 20 feet, the reservoirs would have a net area of about 102 acres; allowing about 25% additional for walls embankments, pumping station, etc., or, say, 23 acres, the total area required at the sewage station would be about 125 acres.

Outfall Tunnels.

It would be very desirable, both on account of obtaining the most favorable conditions at the points of outlet and of minimizing the number of large and costly tunnels, to make both discharges of the day of equal volume without enlarging the capacity of the reservoirs beyond a size necessary to store the maximum flow for any 8-hour period of the day. By a proper method of operation this can be done, the conditions of pressure under which the two daily discharges take place being made very nearly the same. One-half the average daily sewage flow, or 365 million gallons, will therefore be outletted during each 4-hour period.

The average rate of discharge through the tunnels would be:

$665 \times 24/4 = 3,990$ million gallons per 24 hours.

To discharge at the above rate with a velocity of 6 feet per second, a tunnel capacity equivalent to that afforded by 4 tunnels 18′-0″ in diameter would be required.

The velocity at the beginning and ending of discharge would be 7.5 and 4.5 feet per second, respectively.

It is proposed that the tunnels discharge at a point about 3 miles north of the Ambrose Channel light vessel and about 5 miles southeast of Rockaway Point.

Estimates of Cost.

Land:		
In Richmond (Stapleton)	$40,000	
In Brooklyn (Red Hook)	250,000	
In Brooklyn (Navy Yard)	250,000	
In Queens (Steinway)	50,000	
In Queens (Flushing Creek)	5,000	
In Queens (Jamaico Bay)	5,000	
In Brooklyn (Barren Island)	1,250,000	
		$1,850,000
14 Sewers to Barren Island:		
Richmond-Brooklyn Line	$5,450,000	
Manhattan-Brooklyn Line (West)	12,500,000	
Manhattan-Brooklyn Line (East)	14,050,000	
Bronx-Queens-Brooklyn Line	13,650,000	
Queens-Brooklyn Line	4,350,000	
Allowance for Rockaway	1,000,000	
		$51,000,000

Pumping Stations:		
Richmond (Stapleton)	$461,000	
Brooklyn (Red Hook)	714,000	
Brooklyn (Navy Yard)	843,000	
Queens (Steinway)	587,000	
Queens (Flushing Creek)	814,000	
Queens (Jamaica Bay)	103,000	
Brooklyn (Barren Island)	8,040,000	
		$11,560,000
Storage Reservoirs		6,650,000
Outfall Tunnels		51,200,000
		$122,260,000
Engineering and Contingencies, 15%		18,340,000
Total		$140,600,000

15 APPENDIX C.

Disposal of New York's Sewage on Farm Land.

The estimated approximate cost of works for collecting the sewage of New York City, pumping it from Jamaica to, and disposing of it on, sewage farms on Long Island, but exclusive of the cost of land for the sewage farms, follows:

Land for pumping stations in New York City	$625,000
Sewers to main pumping station at Jamaica	51,000,000
Pumping stations in New York City	12,140,000
Gravity conduits, Jamaica to Massapequa	34,500,000
Pumping station at Massapequa	13,500,000
Force mains at Massapequa	10,000,000
Development of sewage farms	11,085,000
	$132,850,000
Engineering and contingencies, 15%	19,930,000
Total	$152,780,000

The main assumptions on which this estimate is based follow:

Works of Capacity Sufficient to Collect and Dispose of the Total Volume of Sewage (Dry Weather Flow Only) of New York City for the Year 1940:

Estimated population in 1940 9,000,000
Estimated mean sewage flow in 1940 .....1,330 mil. gals. per 24 hrs.

The estimated population and sewage flow of the city in 1940, by boroughs, the sewers leading to a main pumping station at Jamaica

and the requirements at the pumping stations in New York City, except the main one, are the same as those contained in Appendix B.

The estimate of cost given is, at the best, but a very rough approximation, and should be considered only as such.

16 APPENDIX D.

Intensive Purification of New York's Sewage.

The estimated approximate cost of works for collecting the sewage of New York City, carrying it to Barren Island, treating it there in Emscher tanks and percolating filters and then discharging it into Rockaway Inlet follows

Land	$4,700,000
Sewers to Barren Island	51,000,000
Pumping stations	12,140,000
Treatment works	49,900,000
Outfall works	5,000,000
	$122,740,000
Engineering and Contingencies, 15%	18,410,000
Total	$141,150,000

The main assumptions on which the estimate is based are as follows:

Works of Capacity Sufficient to Collect and Dispose of the Total Volume of Sewage (Dry Weather Flow Only) of New York City for the Year 1940.

Estimated population in 1940 9,000,000
Estimated mean sewage flow in 1940....1,330 mil. gals. per 24 hrs.

The estimated population and sewage flow of New York in 1940, by boroughs, the sewers leading to Barren Island, and the requirements at all the pumping stations, except the main one, are the same as those contained in Appendix B.

The estimate of cost given above is, at the best, but a very rough approximation, and should be considered only as such.

1 COMPLAINANTS' EXHIBIT No. 148. James D. Maher, Commissioner.

NEW YORK CITY, May 19, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York's Sewage.

II.

Description of the Four Principal Drainage Divisions in That Part of the Metropolitan Sewerage District Which Lies in New York State.*

Metropolitan Sewerage Commission of New York: George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.

NOVEMBER, 1911.

2 *Description of the Four Principal Drainage Divisions in That Part of the Metropolitan Sewerage District Which Lies in New York State.*

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: The studies of the Metropolitan Sewerage Commission from 1908 to 1910 covered a territory of about 720 square miles, about one-half of which lay in the State of New York and the other half in the State of New Jersey. This territory, which the commission outlined, called the Metropolitan Sewerage District, included all the important cities and towns situated on the shores of New York harbor and its immediate drainage areas.

The investigations were fully reported on in April, 1910, at which time the commission expected to go out of existence by statutory limitation.

The commission was continued by the Legislature in 1910 for three years in order that it might make plans and estimates of cost for such main drainage works for New York as its investigations had shown to be necessary. In the work done since April, 1910, the commission has confined itself to the study of main drainage works for that portion of the Metropolitan District which is within the State of New York.

*This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

Considerations Affecting the Division of the Territory.

In Preliminary Report No. I of the Metropolitan Sewerage Commission, dated September, 1911, wherein the feasibility of collecting all the sewage of New York to one central point for disposal was discussed, it was proposed that this authority should be separated into a number of divisions to facilitate the design of a system of main drainage, and in the report of this commission, dated April, 1910, wherein the necessity for this division was foreshadowed, it was suggested that the boundaries of these divisions should be determined partly by the quantities of sewage produced, partly by the facilities which were open in the several localities for disposing of the waste in a sanitary manner and partly by considerations of cost.

It is evident that a rational division of the territory should be based not only upon these considerations, but upon others There should be a due regard for the part of the harbor to be protected; its form, location, extent, depth and the volume of water passing; its uses for traffic, recreation, shellfish culture, bathing, etc., and for the present and probable future state of municipal development on its shores.

For purposes of administration, it was at first thought that the division of the territory should harmonize, if possible, with the separation of the city into boroughs, but a rigid agreement with borough boundaries was soon seen to be impracticable and unnecessary.

In separating the territory into main sewerage divisions, the chief consideration is to provide for an adequate and reasonably economical protection of the harbor water and to accomplish this by means of systems of large collecting sewers and well-situated central stations to which the sewage can be collected, and from which it can be discharged after the removal of more or less of its impurities.

The extent to which the harbor needs to be protected is of fundamental importance in these studies. The commission has found that it will not be necessary to keep all the sewage out of the harbor, for these waters can absorb a large amount of sewage harmlessly and inoffensively. The commission considers that this capacity should be fully utilized, and has undertaken to determine to what extent and in what ways this can be done. A report which will deal especially with the absorptive capacity of the harbor will soon be issued by the commission as Preliminary Report No. III.

The Four Divisions and Their Main Characteristics.

Keeping in mind the considerations which have affected the separation of the territory into divisions and remembering that sewerage systems must conform closely with natural drainage areas, it is easy to comprehend the method adopted by the Metropolitan Sewerage Commission in separating the territory into a number of main sewerage divisions. The drainage areas included within the principal watersheds have been laid down on a map and these areas have then been formed into a few large groups, depending upon the part of the harbor into which their drainage naturally discharged. Here-

after, these groups will be called, by this commission, divisions, and the separate drainage areas within them for which a system of main drainage is designed, leading to a separate outlet, will be termed sub-divisions.

It seems best to designate the several main sewerage divisions according to the parts of the harbor which they were to protect and the subdivisions by a name which will sufficiently indicate the location.

The territory whose drainage flows, or can readily be made to flow, into Jamaica bay is called the Jamaica bay Division.

4 The territory in the Borough of Richmond, or, as it is more generally termed, Staten Island, constitutes the Richmond Division.

The territory on Manhattan Island and in Brooklyn which drains into the Lower East and Lower Hudson rivers and Upper bay constitutes the Lower Hudson river, Lower East river and Bay Divisions.

The territory in the Borough of Northern Queens, in the Borough of The Bronx which naturally drains into the Upper East river, and that part of the Borough of Manhattan and the Borough of The Bronx which naturally drains into the Harlem river constitutes the Upper East river and Harlem Division.

A fuller description of these divisions will be given further on in this report.

The four divisions are markedly dissimilar in topography, density of population and in location with respect to the ocean and to large volumes of swiftly running tidal water, yet the range of main drainage and of sewage disposal problems is not great in each.

The subjects of controlling importance in each division are the opportunities and obstacles which they afford for the discharge of the sewage with a minimum amount of treatment and without producing conditions injurious to the public health and welfare.

The Selection of Central Points for Disposal.

Having tentatively settled upon the main divisions into which it is desirable to divide the territory, the selection of central points to which the sewage can be collected for treatment and disposal became a matter of the utmost importance. Upon the choice of these points depends not only the cost of collecting the sewage, but the method of treating it and the facility with which it can be disposed of after treatment.

It is considered by the commission that as far as practicable, the collecting points should be near the ocean or Long Island sound or close to the unobstructed flow in deep, tidal channels. Points of outlet for untreated sewage should never be situated in shallow, stagnant or remote parts of the harbor. When these favorable conditions cannot be secured, an approach to them should be sought. At any outfall where facilities are lacking for the disposal of the sewage through dilution by large volumes of freely-flowing tidal water, compensation for this lack should be made by a higher degree of treatment for the removal of impurities before the sewage is discharged.

5 It is considered desirable to reduce the number of central points as far as practicable in order to facilitate the ultimate disposal of the sewage, due attention being given to the probability that pumping will have to be employed to some extent and to the fact that for purposes of administration, the works should be concentrated as much as is consistent with due regard to first cost.

The exact degree of purification required for the sewage cannot, at this time, be stated, but an effort should be made to avoid elaborate processes which will require much land and expensive plants and involve large cost for maintenance. The aim should be to make good use of the absorptive capacity of the harbor waters. By good use is meant such use as will do no material harm to the public health and welfare either by producing disease or causing nuisance. In exceptional cases the utmost degree of purification obtainable may be necessary.

Work on the Definite Plans and Estimates.

In making the plans and estimates of cost of the main drainage works for the several divisions of the territory it has been considered by no means necessary that all the lines and grades and sizes shall be finally and exactly fixed. At the same time, it is evident that the outcome of the commission's studies should possess definiteness and take account of the ascertainable conditions of population and topography. For this reason, investigations have been undertaken and efforts made to obtain from the local sewer bureaus, topographical bureaus, and elsewhere, such necessary data as were available and to base upon these carefully considered plans for each division.

The plans which will be the result of this work are to be regarded as the outcome of careful studies based on the outlook in the year 1911 for the municipal development of the region under consideration, and on the existing state of the art of sewage disposal. All the work planned will not be needed in the immediate future, but it is regarded as essential that such main drainage works as are undertaken should in general conform to these plans and be made part of the general scheme.

The possibility that a more complete system of protecting the waters than that outlined here may be needed in the distant future is being kept in mind in preparing the plans. It is believed by the commission that if greater protection is needed, it can be secured by extending the treatment works which the commission will propose, without undue sacrifice of any part of completed structures.

In designing the main drainage works, careful account will be taken of the character of sewers, where any sewers exist. Most
6 of the sewers already constructed by the city were built to accommodate house, factory and storm water drainage. Where no sewers have been built or have been designed, and a separate system seems to the commission the more suitable, it will be assumed that a separate system will be constructed and provisions will be made in the plans for sewage collected in this way.

Jamaica Bay Division.

The Jamaica Bay Division faces directly upon the Atlantic ocean; it is in little danger of being affected by the drainage of the rest of the City; and the disposal of its sewage is likely to have little or no effect upon the other divisions.

This division is bounded by a natural ridge, which begins at Bensonhurst, Gravesend Bay, runs in a general northeasterly direction to the easterly boundary of New York City near Lake Surprise, continues to a point just west of Roslyn, bends south and extends to Lynbrook, from which it follows the height of land along the Rockaway peninsula to the City line and the ocean.

The Jamaica Bay Division covers a total area of about 103 square miles. Of this, about 76 are land and 27 water or low-lying marshy islands.

The bay is very shallow except in its southwestern part, where a deep channel enters from the ocean and, dividing into numerous branches, flows among the islands.

The refreshing action which the tide produces upon the bay is large, for although the currents do not flow in one direction (the most advantageous from the point of view of ordinary flushing), the bay is so shallow that a large proportion of its water leaves at each falling tide, and is replaced as the tide rises. Calculation shows that the bay half empties itself at each tide. The volume of water contained at low water is estimated to be 2,400 million cubic feet, and the mean tidal prism 2,000 million cubic feet. The large area of the water surface, as compared with the shallow depth, is favorable to the absorption of oxygen from the atmosphere and to a thorough commingling of the waters, two conditions which favor the bay as a place for the harmless and inoffensive assimilation of sewage matters.

On the other hand, there are large areas of bottom exposed at low tide which would become very offensive if polluted by sewage. The extensive shallow parts of the bay support dense growths of vegetable matter which, decomposing, sometimes place a considerable burden upon the dissolved oxygen which the water contains. Probably four-fifths of the bottom is covered with black mud in which vegetable and animal organisms in great variety exist. The mud varies in consistency from a tough, dense, clayey mass to a light ooze. It is always black and generally putrefactive. The odors which now arise from the mud are such as are commonly noticeable at the sea-side, and are not generally objected to.

Clams, both the soft shell, Mya arenaria, and the hard shell, Venus mercenaria, grow luxuriantly, and are taken from the waters in large numbers. Soft shell clams are in places taken under circumstances which lead to the opinion that they are polluted.

Oysters are planted extensively on the harder bottoms near the sides of the main channels in the southwestern part of the bay. The oysters grow well and command good prices in the market. Many are eaten raw, although the typical oysters from this vicinity, formerly known as Rockaways, were large and generally used for cooking.

Fish do not enter Jamaica bay from the ocean except in small numbers and at certain seasons of year, although the fishing a few miles outside of the inlet is usually excellent. A numerous fleet of fishing boats with headquarters inside the bay is constantly engaged in angling in the ocean.

Much of the territory included in the Jamaica Bay Division is in a state of transition from open, rural country to built-up city conditions. Close along the southern shore and two miles and more from the northern shore are extensive sections which possess the characteristic features of permanent development. The territory in the northeast is sparsely settled.

It has been proposed by the City of New York and National Government to construct extensive engineering works to convert Jamaica bay into a safe and convenient harbor for ocean-going vessels and, if this is done, as now appears likely, the natural characteristics of the bay will, in a large part, give place to deeper, straighter, wider channels, canals and bulkheaded shores.

The total population of the Jamaica Bay Division was, in the year 1910, about 366,000. The population is growing rapidly and is expected to reach about 1,548,500 in 1950 or 1960.

Sewage now enters the bay from a few large sewers on the northern and western shores and from many small outlets on the south. The large sewers are mostly connected with sewage disposal works designed to operate on the principle of chemical precipitation. These works are all inefficient and have repeatedly been criticised adversely by and for the Bureaus of Sewers of the boroughs in which they are situated.

8 Richmond Division.

The Richmond Division includes the whole of Staten Island. The total area of land is about 57 square miles of which about one sixth is marsh.

Staten Island is, in part, rough, high and hilly and, in part, low-lying and flat. Except at the northern end, the low land lies near the shores. The high parts of the island lie along a broad ridge which extends in a northeasterly and southwesterly direction at a distance of from two to four miles from the shores of Lower New York bay.

The waters of Lower New York bay are shallow for a long distance seaward from the Staten Island shore. On this account, and for the reason that this shore is comparatively inaccessible by land transportation, and because of the exposure of this part of the island to the open sea, it seems likely that commercial development of this water front will long remain dormant as now. The south shore is now occupied largely by summer residents and by permanent settlers who live in small villages near the foot of the hills. There are several extensively patronized bathing beaches on the south shore of Staten Island. The west side of the island, bordered by the Arthur Kill, has been developed to some extent for manufacturing, but land values here have not advanced as rapidly as might be ex-

pected, apparently, because much of the land consists of salt meadows.

The principal residence and business parts of the Richmond Division lie at the north end of the island. Here numerous large towns are situated, each fronting on Upper New York bay or the Kill von Kull and bordered on the other sides by other towns or the open country. The business done is chiefly manufacturing and maritime and is carried on close to the water's edge.

At the present time, 1911, the population of Staten Island is about 90,000. The towns are partly sewered and in many cases the sewers are on the combined plan. There are about 30 outlets from which sewage is discharged without treatment into the nearest large body of water. It is certain that the population of Staten Island will increase for many years and that this territory will continue to grow with the rest of New York. Up to the present time, this division has not benefited to the extent which might be expected from its excellent position and other natural advantages.

Lower Hudson, Lower East River and Bay Division.

The greatest part of the most densely settled portion of New York City is included in the Lower Hudson, Lower East River and
9 Bay Division. This division includes all of the Borough of Manhattan except that portion at the northeastern end which naturally drains into the Harlem river; all of the Borough of Brooklyn except that part which naturally drains into Jamaica Bay, and the eastern end of Gravesend bay; and that part of the Borough of Queens which naturally drains into the East river south of Lawrence Point near Hell Gate. To the southeast lies the Jamaica Bay Division, to the northeast the Upper East River and Harlem Division and to the southwest the Richmond Division.

The Lower Hudson, Lower East River and Bay Division affords serious obstacles to the design of sewerage works on account of the very large quantities of sewage to be dealt with, the absence of low-cost land and because of the slight elevation of the shores above tide water. Nearly all of the extensive shore line is low-lying and flat. Much of the originally indented shore has been filled in so that the water-front now appears upon the map to be remarkably smooth and uniform. The average tidal range is 4.4 near the center of the division.

Practically the whole division is now thoroughly sewered on the combined plan. The sewers discharge near the level of low tide and, except in the Borough of Manhattan, usually at the bulkhead or shore line. The sewers of Manhattan are, for the most part, carried out nearly to the outer ends of the piers which project perpendicularly from the shores at frequent intervals.

More than half of the land in the Lower Hudson, Lower East River and Harlem Division is built up in the compact manner characteristic of the most thickly settled parts of great cities. The other half is rapidly becoming permanently settled.

The Boroughs of Manhattan and Brooklyn, besides being great

residence centers, contain a large part of the industrial establishments which make New York the leading manufacturing center of the United States.

The total population of the Lower Hudson, Lower East River and Bay division was in 1910 about 3,230,000. It is estimated that this population will be 5,560,000 by 1940.

There are about 200 sewer outlets in this division.

The waters into which the crude sewage of this division is now discharged are those arms of the harbor from which the division takes its name. The Hudson is a broad, deep waterway, capable of accommodating large sea going vessels at any point between its shores from its mouth at the junction with the Upper bay to a point near the northern limit of the Metropolitan Sewerage District, except on the New Jersey side, which is somewhat shallow, undeveloped and difficult for land transportation, from a point about four miles above the mouth of the river and running north.

Upper New York bay, while deep in the main channels, contains extensive shoals on its east and west sides. The shallow flats on the west side of the bay are noteworthy in this respect, for they underlie about one-third of the entire water surface at depths of from 2 to 10 feet below low tide. The shoal on the east side of the bay extends for a distance of about 3 miles, and is overlaid by about 15 feet of water at low tide.

The Lower East river joins Upper New York bay close to the mouth of the Hudson. The East river is narrower and swifter than the Hudson, but of about the same depth. The East river is in reality a strait which joins Upper New York bay with Long Island sound. Sea-going vessels can traverse any part of the Lower East river, and reach any of its docks and piers.

These three large sections of the harbor, the Lower Hudson, Lower East river and Upper bay have some features in common and some differences which it is desirable to keep in mind in considering the question of a sanitary disposal of the sewage. The tidal range is practically the same. Under ordinary circumstances, practically the same water circulates back and forth in the bay, East river and Hudson river, which together may be likened to the stem and arms of the capital letter Y. At dry seasons of the year there is comparatively little net movement of the water to sea. After continued heavy rains the Hudson discharges a heavy flow of water from the land. The discharge of the Hudson at times of storm produces effects which are plainly visible throughout the Lower East river and Upper bay. There is marked change in the color and turbidity of the water. The change is sudden; the effects wear away slowly. Normally the water is of an olive green and slightly turbid appearance.

Upper East River and Harlem Division.

The Upper East River and Harlem Division includes nearly the whole of the Borough of The Bronx, that part of Manhattan Island

which naturally drains to the Harlem river, and that part of the Borough of Queens, whose natural drainage flows to the East river, east of Lawrence Point near Hell Gate.

The topography and municipal development of this division is various in the extreme. The elevation of land in the western part of The Bronx is high, the Harlem river flowing for part of its way between steep banks. To the east, steep, narrow valleys run between parallel ridges in a north and south direction, the land gradually becoming more uniform in contour eastwardly.

11 The topography of that part of this division which lies in Queens is notable for its sloping land, situated at a considerable elevation, and its extensive low-lying tidal meadows opening into the East river.

Both sides of the Upper East river are characterized by elevated promontories and deeply placed bays. The bays are all very shallow and their bottoms are covered with black mud. A natural channel suitable for vessels drawing not over 24 feet of water runs between the headlands throughout the length of this part of the river.

Flushing bay is the most notable example of the numerous shallow estuaries which open into the river. This bay, which is about a mile and a quarter wide at its junction with the East river has, with the tidal meadows at its head, a tidal length of 5 miles. Shallow water extends from the mouth of this bay for a mile and a half. The East river itself is about a mile and a half wide just east of the mouth of Flushing bay. It is important to note the physical conditions of these bays and of the extensive low-lying meadow lands at their heads, for these conditions have important bearings on the problem of sewage disposal. They make the sewage more difficult both to collect and to dispose of.

The ship channel through the Upper East river is narrower than the channel in the Hudson or Lower East river and less deep, but the rise and fall of tide are somewhat greater. The incoming tide which comes in from the ocean by way of the Upper bay meets that which comes in by way of the sound in the Upper East river, a fact which gives to this arm of the harbor considerable hydrographic interest and has some bearing on the problem of sewage disposal.

The Harlem river joins the Hudson with the East river and forms the northern boundary of Manhattan. This stream is narrow and shallow compared with the other main parts of the harbor, its present use being largely confined to a small amount of shipping. At the southern end, the shores of the Harlem are closely occupied, *which* the remainder is largely unimproved.

Municipal conditions vary widely in this division. There is an area of several square miles in the southwestern part of The Bronx which is almost as densely settled as any part of the City of New York, and there are parts of Queens which possess every semblance of rural remoteness. That part of Manhattan which is comprised in this division includes a section which is said to be occupied by the most densely congested population in the world.

In a large part of this division, rural and semi-rural conditions exist. Isolated towns with large residence populations are growing

and will doubtless ultimately converge, while new centers are constantly being established through the efforts of enterprising real estate operators. The present population (1910) of this
12 division was about 1,103,000. By 1940 it is expected that the population will be 2,400,000.

The present number of sewer outlets in this division is about 86. Nearly all the sewers are constructed on the combined plan. There are many large collecting or trunk sewers already built and others contemplated.

Respectfully submitted,

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK.
GEORGE A. SOPER, *President.*
JAMES H. FUERTES, *Secretary.*
H. DE B. PARSONS.
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

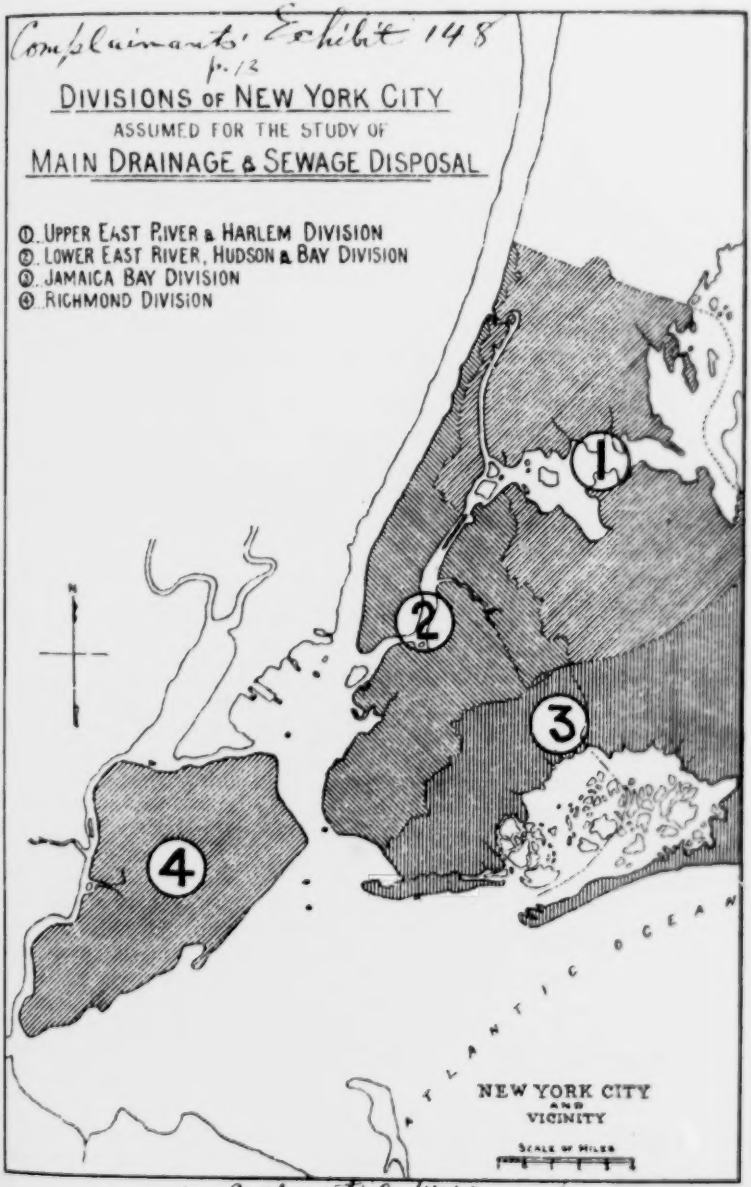
(Here follows diagram, page 13, Complainants' Exhibit No. 148.)

Complainants' Exhibit 148
p. 12

DIVISIONS OF NEW YORK CITY

ASSUMED FOR THE STUDY OF

MAIN DRAINAGE & SEWAGE DISPOSAL



13 Complainants' Exhibit No. 148

6 COMPLAINANTS' EXHIBIT No. 149.

James D. Maher, Commissioner.

Preliminary Reports on the Disposal of New York's Sewage.

III.

Study of the Collection and Disposal of the Sewage of the Jamaica Bay Division.*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sopysmith, Linsly R. Williams, Commissioners.

November, 1911.

NEW YORK CITY, May 19th, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

1 Study of the Collection and Disposal of the Sewage of the Jamaica Bay Division.

December 2, 1911.

Honorable William J. Gaynor, Mayor of the City of New York.

SIR: Following is a report upon a general plan of main drainage and sewage disposal for part of the Boroughs of Brooklyn and Queens whose natural drainage flows into Jamaica Bay.

The design herein embodied is the result of careful study based on the outlook in the year 1912 for the municipal development of the region under consideration and on the existing state of the art of sewage disposal.

All the work planned will not be required in the immediate future, but it is regarded as necessary that such main drainage work as is undertaken by the city should conform to these plans, or such modifications of them as may be determined upon. The possibility that a more complete system of main drainage than that here proposed may be needed in the very distant future has been kept in mind in preparing these plans, and it is believed that the works can be adopted so as to afford a more thorough protection of the harbor, if that is ultimately needed.

---

*This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

Boundaries of the Division.

As proposed in Preliminary Report No. 1, of the Metropolitan Sewerage Commission, dated September, 1911, the Commission has separated the City of New York into a number of divisions to facilitate the design of a system of main drainage for the protection of the harbor waters against sewage pollution. The principal divisions are five in number, and take their names from the waters into which their natural drainage discharges.

The territory included in the Jamaica Bay division lies in the southeastern part of the City of New York.

The division is bounded by an irregular line following the watershed from 23d Avenue and Gravesend Bay, Borough of Brooklyn, to a point about three-quarters of a mile east of Prospect Park, thence northeasterly to the easterly boundary of New York City near Creedmoor, thence southerly following the city boundary to the ocean. The total area of land to bulkhead line is about
2 83.8 square miles. Of this area about 35.5 square miles lie in Brooklyn and 48.3 in Queens.

General Features of the Division.

The principal topographical features of this division include a natural ridge, which forms the northern boundary of the territory, and from which the land slopes gradually to low-lying tidal meadows; the large, shallow expanse of Jamaica Bay, studded with numerous marshy islands and hummocks, intercepted with narrow, crooked channels; and, finally, a protective barrier formed by the low, sandy shore of the Rockaway peninsula, separating the bay and the rest of the division from the open waters of the Atlantic Ocean. In places, the low-lying meadows to the north of the bay extend for over two miles. Back of the meadows, the upland begins and runs in a slightly elevated tract which rises, on an average, 4 or 5 feet per thousand, until near the northern boundary of the division, where the elevation increases more rapidly.

The Jamaica Bay division is partly built up. Parts of it include a thickly settled district in Brooklyn, parts consist of separated country villages, parts of strictly rural territory, including farms, and parts of large stretches of unprofitable salt marshes. Finally, there are some largely attended day summer resorts.

The population of the whole territory in 1910 was about 366,000, including 13,000 residents of Brooklyn, now draining to Gravesend Bay, which it is proposed to include in the Jamaica Bay system. The density of settlement, as shown by dividing the population by the area, gives but a poor idea of the extent to which the division is settled, for the reason that there are large, unpopulated sections and some rather densely peopled parts. The density thus divisionally determined varies between sixty persons per acre, at a point in Brooklyn, to one in ten acres near the head of Jamaica Bay in Queens.

Probable Future of Jamaica Bay.

Coney Island and Rockaway Beach, each of which is visited by hundreds of thousands of visitors on a summer holiday, are in this division. Parts of the division have increased largely in population during recent years and are still growing rapidly under the fostering operations of real estate operators.

The shores of the bay are now devoted almost exclusively to the uses of a transient summer population and the waters to sailing, bathing and the cultivation of shell fish.

The shell fish interests of Jamaica Bay are extensive. These waters, which first became famous for oyster culture about
3 fifty years ago, are now much used for growing oysters and hard and soft shell clams. The beds are located on the bottom and sides of the natural main channels. The future development of the bay will make shell fish culture unsafe from the standpoint of disease.

Unlike the cultivation of oysters and hard shell clams, which is carried on by means of seed brought from elsewhere, the muddy shores of Jamaica Bay afford seemingly endless supplies of soft shell clams. These clams are free to any one who will gather them. Persons may be seen digging soft clams in practically all parts of Jamaica Bay during low tides.

In summer hundreds of small boats ply the waters on Sundays and holidays and the water front in those parts of the bay which are most easily accessible are settled with crowded communities which live in tents and cottages of an inexpensive nature.

The future of this division is uncertain, although there is a definite plan for the development of Jamaica Bay for commercial purposes. This plan, which was proposed by a special body created for the purpose, and known as the Jamaica Bay Improvement Commission, involves extensive engineering works. It is proposed to construct a substantial and regular shore line, deep, wide channels for ocean-going vessels, and harbor approaches for the entrance at Jamaica inlet.

It is also proposed to construct a number of canals on the northern shore, each about 300 or 400 feet in width and from 4,500 to 12,000 feet long, extending back into the territory at places where natural creeks exist, so as to increase the water front. The object of this development is to increase the shipping facilities of New York by providing additional wharves, storehouses, terminal facilities and space for the handling of vessels. At the present time no business of this kind exists, or is possible, in Jamaica Bay, owing to the shallowness of the water, lack of railroad facilities and store-house accommodations.

As to the future of the beaches known as Coney Island and Rockaway, it seems likely that they will long remain pleasure resorts, in spite of any commercial development which will occur in the neighborhood. The situation of Coney Island makes it comparatively remote from the shipping centers and the ocean front of Rockaway

Beach renders it, to a considerable extent, independent of the natural resources of Jamaica Bay which commercial conditions may destroy.

It is necessary to carefully consider how the waters of Jamaica Bay are now used or are likely to be used in future in order to determine the degree of thoroughness with which these waters are to be protected from sewage pollution. If the waters are to be kept pure enough for bathing, boating and shellfish culture, a different method of dealing with the sewage disposal problem of this division should be followed than if the bay is to be devoted to commercial purposes.

4

From a careful study of the Jamaica Bay Improvement Commission's reports, it seems improbable that the waters of this division could be used both for shipping and the other purposes to which they are now put. The development of the bay for commerce would seem necessarily to exclude its use for pleasure; and, conversely, if the bay is to be maintained for purposes of recreation, its value will be seriously impaired by the developments of commerce. So far as the Metropolitan Sewerage Commission can foresee, the future of Jamaica Bay will lie along the lines proposed by the Jamaica Bay Improvement Commission. It appears that an agreement to develop this harbor for shipping has been entered into between the U. S. Government and the City of New York, that outline plans have been officially adopted and money appropriated to begin the work.

That the development of the area draining to Jamaica Bay will be rapid, probably will not be disputed. The chief causes for this are: First, the improvements recently made, and those in contemplation, by the Long Island Railroad Co. and by the Brooklyn Rapid Transit Co.; and secondly, Jamaica is probably destined to be of considerable importance as the local focus of railroad lines to all parts of Long Island—to the west by the Pennsylvania tunnels and to New England by the projected bridge across the East River near Hell Gate. Already large sums of money have been appropriated for improvements in this vicinity.

The effect of this development will be felt all along the main line of the branch of the Long Island Railroad, which extends east and west near the northern limit of the Jamaica Bay Division. The rapid transit lines and the southern branches of the Long Island Railroad will afford quick transportation from nearly all points in the drainage area to Brooklyn and Manhattan.

The projected Jamaica Bay Improvement, already mentioned, will provide economical entrance for coastwise and inland shipping. Building material can be delivered by water at low shipping rates, stimulating improvements on large areas accessible to the water front, which now are unoccupied and of little value.

It has been proposed to establish a barge canal terminal in Jamaica Bay. The length of water front and the large marginal areas available cannot be found elsewhere. The trip from Norton Point to Rockaway Point via the ocean can be obviated by the construction of the Gravesend ship canal, which is understood to be included in the project for this section of Brooklyn that has been adopted by the city authorities.

5 **Probable Future Population of the Division.**

In planning for the main drainage of this division, it has not seemed best to attempt to anticipate conditions more than 40 or 50 years in advance of the present time, for the reason that conditions may arise which will result in an increase or shifting of population quite different from any that can now be foreseen. A material variation from forecast population is more to be expected in the thinly populated and rapidly improving areas than in those where, as in much of the Brooklyn area, populations are dense and the conditions which affect growth are well established. For this reason, estimates for sewerage have been based upon a population in the Brooklyn portion of this division as forecasted for 1960, while in Queens the populations are forecasted for 1950.

The expected populations are, for the area lying in

Brooklyn	884,100
Queens	531,600
Total population planned for	1,415,700

General Outline of the Proposed Plan.

An outline of the plan which is being worked out follows:

The sewage is to be collected by the separate system, so far as possible. Where this is not feasible, the sewage provided for is confined to the dry weather flow. Allowance is made for an unavoidable inflow of ground water.

Where sewers have been constructed on the combined plan, it is proposed to intercept the dry-weather flow and provide storm water overflows above the points of interception. In this way a certain amount of house sewage mixed with storm water will pass to the bay during storms, but the amount which will enter in this way will be so small in comparison with the diluting water, that no objectionable conditions are to be apprehended from this cause.

A serious consideration is the street filth and grit which will be carried down with the surface water. This might seriously pollute and form deposits in the bay. The dissolved organic matter will be taken care of by the large volume of water with which it will be diluted, but the floating solids and grit should be removed by screening and grit chambers placed near the outlets of the more important storm water drains.

The projected long canals mentioned earlier in this report will be most difficult to maintain in an unpolluted condition. There will be but little flow through them and practically no flushing effect 6 from the tides. These long canals may become nuisances similar to Gowanus Canal and Newtown Creek, unless proper measures are taken to protect them.

The entire area can be divided into two subdivisions termed respectively the Eastern Jamaica subdivision and the Western Jamaica subdivision. Each will have a distinct system of collection and disposal.

The Western Jamaica subdivision will be the larger. It will collect the sewage from a population of 1,192,400 in 1960, located on about 49 square miles lying north of Jamaica Bay and west of Cornell Creek, and east of Ulmer Park. The sewage from this territory may be expected to amount to as much as 166 million gallons per day in 1960. It will be delivered to a pumping station to be located near Flatlash Avenue and Avenue X. From this point it will be pumped through force mains to Barren Island, where it will be treated, and the effluent discharged through submerged outlets into Rockaway inlet.

In the Eastern Jamaica subdivision there will be about 38 million gallons of sewage collected daily in 1950. This will be from a population of 223,300 on the 27.4 square miles of Queens, which lie to the southeast of Cornell Creek. This Eastern Jamaica sub-division is divided into two separate areas by Nassau County, which borders the head of the bay, the sewage from which is collected separately but carried to a common treatment plant on Jo Cos Marsh. The northerly area is expected to contribute 21.6 million gallons of sewage per day from a population of 111,800 distributed over 19.6 sq. mi. of territory, while the southerly area, comprising Far Rockaway and the Rockaway peninsula, is expected to contribute 16.5 million gallons per day from a population of 111,500 on 7.8 sq. mi.

From the northerly area the sewage will be brought to a pumping station near the Rockaway turnpike and Springfield road; and on the southerly area collecting sewers from the east and west will collect the sewage to a pumping station near Rockaway boulevard and Lucia avenue, Edgemere. From the pumping stations the entire volume will be pumped through submerged mains to a plant where the sewage will be treated on Jo Cos marsh. The effluent will be discharged into Broad channel.

The operation of the treatment works to be located at Barren Island and Jo Cos marsh will be restricted to house sewage, with such manufacturing wastes as it may be found best to admit into the sewers.

Western Jamaica Subdivision.

It is intended that the intercepting sewer of this subdivision, called the Flatlands-Jamaica interceptor, shall start with a diameter of 5' 4" in the Old South road north of the present Jamaica Disposal Works. It will pass under the sewer from Jamaica and intercept the sewage from that division.

7 The sewage from the low-lying area to the south will be collected at the present disposal works for Jamaica. This station will then be converted into a pumping plant, and the sewage will be pumped into the interceptor. At Panama Street the intercepting sewer passes under the Panama Street sewers; then under the Brooklyn aqueduct, the location of which controls the elevation of the interceptor. At the borough line and Cozine Street the diameter is to be 8' 6". The sewage collected at the present East New York disposal plant is to be lifted into the interceptor in Vandalia Avenue.

Assuming that Fresh Creek will be dredged for purposes of naviga-

tion, it will be best to cross under the creek by a siphon rather than carry the interceptor by a long detour around the head of the proposed basin.

At the head of Paerdegat basin, as well as at Hendrix Street, the existing storm drains will pass over without interfering with the flow by depressing the arch of the interceptor, but the domestic sewage collected at this point will have to be pumped into the interceptor. On Avenue T, between Ralph Street and Flatbush Avenue, the diameter is to be 14′ 4″. The invert is to be about 16′ below mean tide level.

At Avenue V and 11th Street, Bensonhurst, a pumping station is now being built to pump the sewage of the neighborhood to the 92d Street outlet near The Narrows. The sewer leading to this outlet eventually will be too small and it is proposed to divert this sewage by means of a sewer, called the Gravesend interceptor, to the east when conditions require the change. The sewers will increase from 4′ 9″ to 7′ 3″ diameter, and meet the interceptor from Jamaica at Flatbush Avenue. The present Coney Island sewage disposal plants will be abandoned or utilized as pumping stations, delivering sewage to pumps to be installed at Ocean Parkway, near Avenue W. The sewage delivered to the pumps at the present Shellbank Creek plant will be pumped to the interceptor.

From Avenue T the sewage will flow through twin sewers about 10′ 3″ square to the main pumping station. Here centrifugal pumps of capacity to lift 350 million gallons per day 35 feet will be installed. This is the only pumping station required on the line of the interceptors. Two 7′ 2″ force mains will then convey the sewage to the disposal plant at Barren Island.

Barren Island will probably be found to be a most suitable point at which to treat and dispose of the sewage. The sewage will be carried to this point by what is called the Barren Island force main. The area of land here is ample; the land belongs to the city; garbage reduction works are already located there; there are no residences in the vicinity except for the workmen employed at the reduction plant; the land is of suitable elevation and believed to furnish, below the surface mud, good material for foundations; it is accessible for transportation by water; on the south it forms one shore of Rockaway inlet, which, on account of its depth, swift currents and proximity to the ocean, furnishes an admirable body of water into which to discharge the effluent.

The degree of purification that will be required is not known at this time. A rough computation indicates that if all the sewage which would naturally drain to Jamaica Bay by 1960 were thoroughly diffused therein, the sewage would, under ordinary conditions, be diluted by about 147 volumes of water at times of low tide. This would be about six to seven times the amount of theoretical dilution required to provide sufficient oxygen to digest the organic matter during the summer months, the most unfavorable of the year.

As this ideal condition cannot be relied upon, treatment to remove the grosser solids and a certain part of the dissolved impurities must ultimately be provided. In order to show approximately the cost of

the masonry works when this territory shall have become occupied to the extent above described, it is assumed that the sewage will then have to be subjected to clarification in settling tanks and further treatment by sprinkling filters and settling basins. About 100 acres of land will be ultimately required for the entire plant.

The effluent from the plant will flow through four submerged pipe lines and discharge in the deep water of Rockaway inlet. The inoffensive sludge from the settling tanks can be used for many years to fill in marsh lands near the plant, or, if preferred, it can be dumped at sea.

The estimated cost of construction of this system for the full future estimated population is:

Interceptors	75,450	lin. ft.	$4,321,600
Siphons	1,150	" "	77,600
Pumping stations	5	" "	755,600
Force mains	9,400	" "	356,200
Treatment plant	.....		4,623,100
Outfall pipes	3,000	" "	154,150
Contingencies	15%		1,541,600
Total cost			$11,850,000

This sum need not all be expended at once, but those portions built should be in accordance with the complete plan, so far as practicable. The construction of some parts of the pumping plants, siphons, treatment plant and outlet pipes can be deferred for many years.

The area now draining to Paerdegat and the 26th Ward and Jamaica disposal plants require immediate relief. This relief will probably have to be met in part by temporary measures. It is desirable that plans for this portion of the interceptor leading to Barren Island be prepared and the work constructed at the earliest opportunity.

9

Eastern Jamaica Subdivision.

The northern or Springfield collector starts at the intersection of the Herrick Plank road and Springfield road with a size of 2' 2" x 3' 3" and runs southerly through Springfield to the Rockaway turnpike, where the diameter is 4' 6". Here there will be a pumping station provided with centrifugal pumps of sufficient capacity to lift 40 million gallons per day 77 feet. The sewage of the entire subdistrict will thus be conveyed across the intervening marshes and under the proposed channel for navigation to the Jo Cos Marsh disposal plant through a force main 33" in diameter, called the Springfield force main.

The Rockaway collector will start with a diameter 21" near Belle harbor, where it will receive the sewage from Rockaway park and the west from a pumping station located near Fifth and Newport avenues.

Running easterly along Rockaway boulevard, with pumping stations at Seaside, Hammels and Arverne, it will reach, with a diameter

of 45", a main pumping station at Edgemere. On the east, sewage collecting at the present Far Rockaway disposal plant will be pumped through a 12" cast-iron force main to Mott avenue and Sheridan boulevard from which a gravity collector, increasing in size from 30 to 36 inches, will run to the Edgemere pumping station. At Channel avenue this collector receives, from a 12" force main, the sewage collecting to the existing ejector station near Ocean and Channel avenues.

The Edgemere pumping station will be provided with centrifugal pumps of capacity to lift 30 million gallons per day 40 feet. The sewage of the entire southern sub-district will thus be carried by a 30-inch force main to Jo Cos Marsh, crossing under the proposed channel for navigation on the way, and called the Rockaway force main.

Jo Cos Marsh has been selected as a suitable location for treatment works, as it is at present waste land and centrally located with reference to the drainage area. It is, at the same time, a good distance from improved property. Finally, it is adjacent to the junction of Hassock Creek and Broad Channel which provide as favorable conditions for dilution as are to be had at the upper end of the bay. The currents depend largely, however, upon the wind. The oscillations of the tide are not sufficient to dispose of a large volume of putrescible sewage. The plan provides for the sewage to be given thorough treatment by settling tanks, sprinkling filters and settling basins. The works will cover about 30 acres of ground by 1950.

The effluent will be conveyed by two outlet pipes 42" in diameter, one to Hassock Creek and one to Broad Channel. The sludge can be used to fill marsh lands or it can be dumped at sea.

The estimated cost of construction of this system for the full estimated future population is as follows:

Interceptors	40,025	lin. ft.	$511,000
Pumping stations	7		79,996
Force mains	25,725	" "	330,070
Treatment plant	.....		1,061,340
Outfall pipes	3,900		90,600
Contingencies	15%		310,990
Total cost			$2,383,000

Much of the cost can be deferred for an indefinite time. Such portions as are necessary to care for the sewage of Rockaway and Far Rockaway should be provided at an early date.

Summary.

Following is a summary of the more important data concerning the proposed sewerage of the Jamaica Bay division.

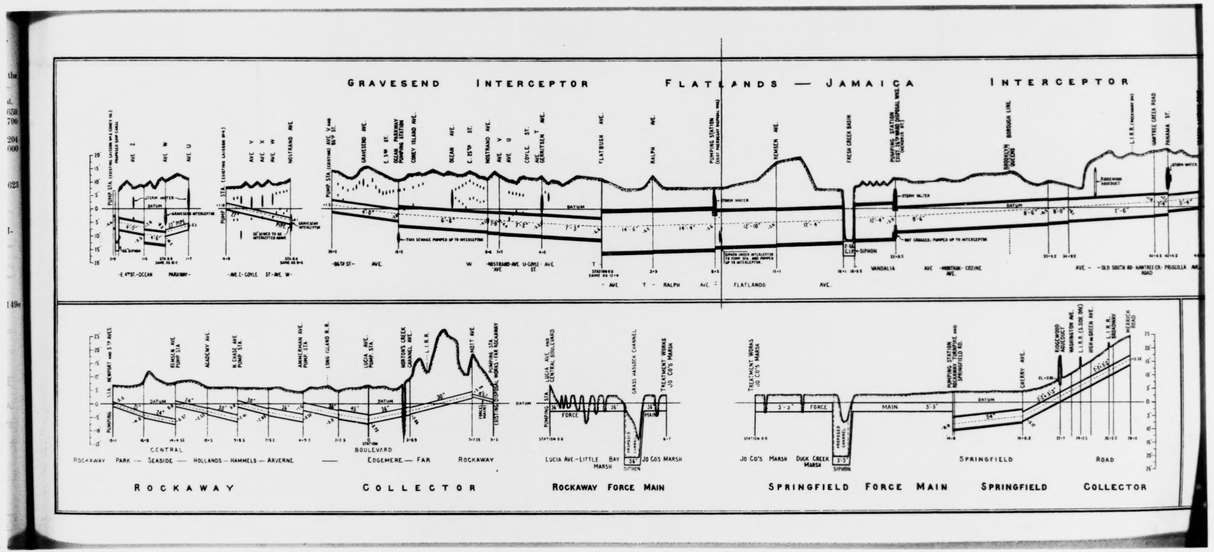
	Barren Island.	Jo Cos Marsh.	Total.
Area drained, acres.....	35,739	17,920	53,659
Population served	1,192,400*	223,300**	1,415,700
Mean volume of sewage—million gallons daily..	166	38	204
Cost of works.....	$11,830,000	$2,383,000	$14,213,000
Annual charges including interest at 4½% and sinking fund for 50 years	$964,643	$239,980	$1,204,623

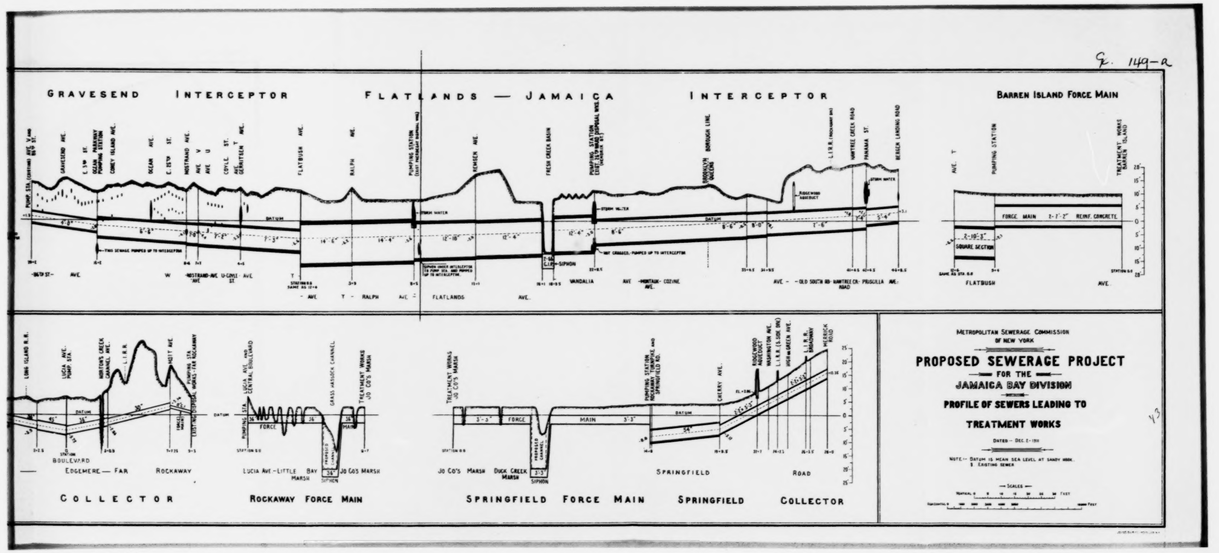
*Estimated for year 1960.
** " " " 1950.

Respectfully submitted,

METROPOLITAN SEWERAGE COMMISSION.
GEORGE A. SOPER, *President.*
JAMES H. FUERTES, *Secretary.*
H. DE B. PARSONS
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

(Here follow two maps marked Complainants' Exhibits Nos. 149*a* and 149*b*.)


GRAVESEND INTERCEPTOR
FLATLANDS — JAMAICA INTERCEPTOR
ROCKAWAY
COLLECTOR
ROCKAWAY FORCE MAIN
SPRINGFIELD FORCE MAIN
SPRINGFIELD
COLLECTOR


GRAVESEND INTERCEPTOR
FLATLANDS — JAMAICA INTERCEPTOR
BARREN ISLAND FORCE MAIN
COLLECTOR
ROCKAWAY FORCE MAIN
SPRINGFIELD FORCE MAIN
SPRINGFIELD
COLLECTOR
METROPOLITAN SEWERAGE COMMISSION OF NEW YORK
PROPOSED SEWERAGE PROJECT
FOR THE
JAMAICA BAY DIVISION
PROFILE OF SEWERS LEADING TO
TREATMENT WORKS

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

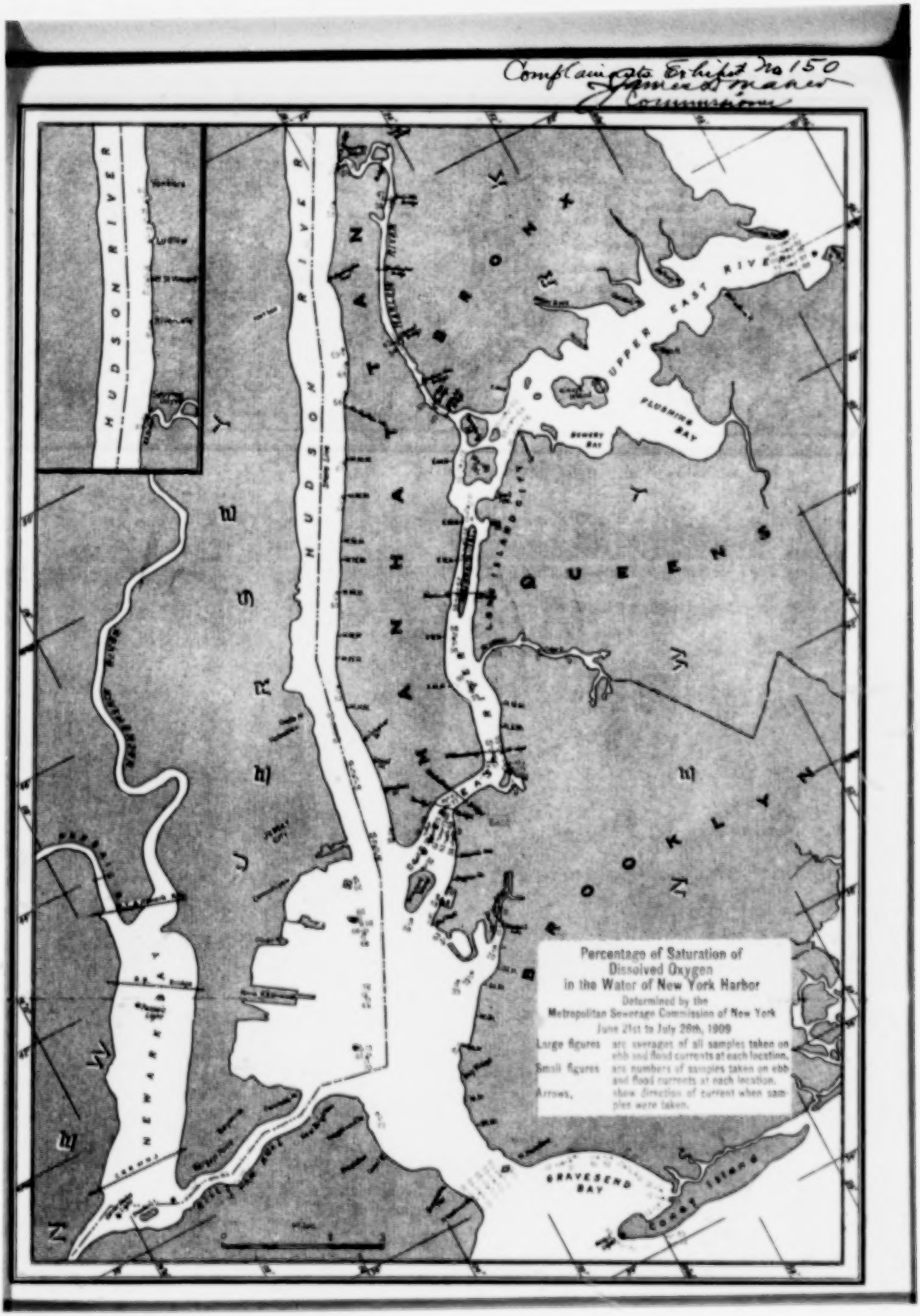
VS.

STATE OF NEW JERSEY ET AL.

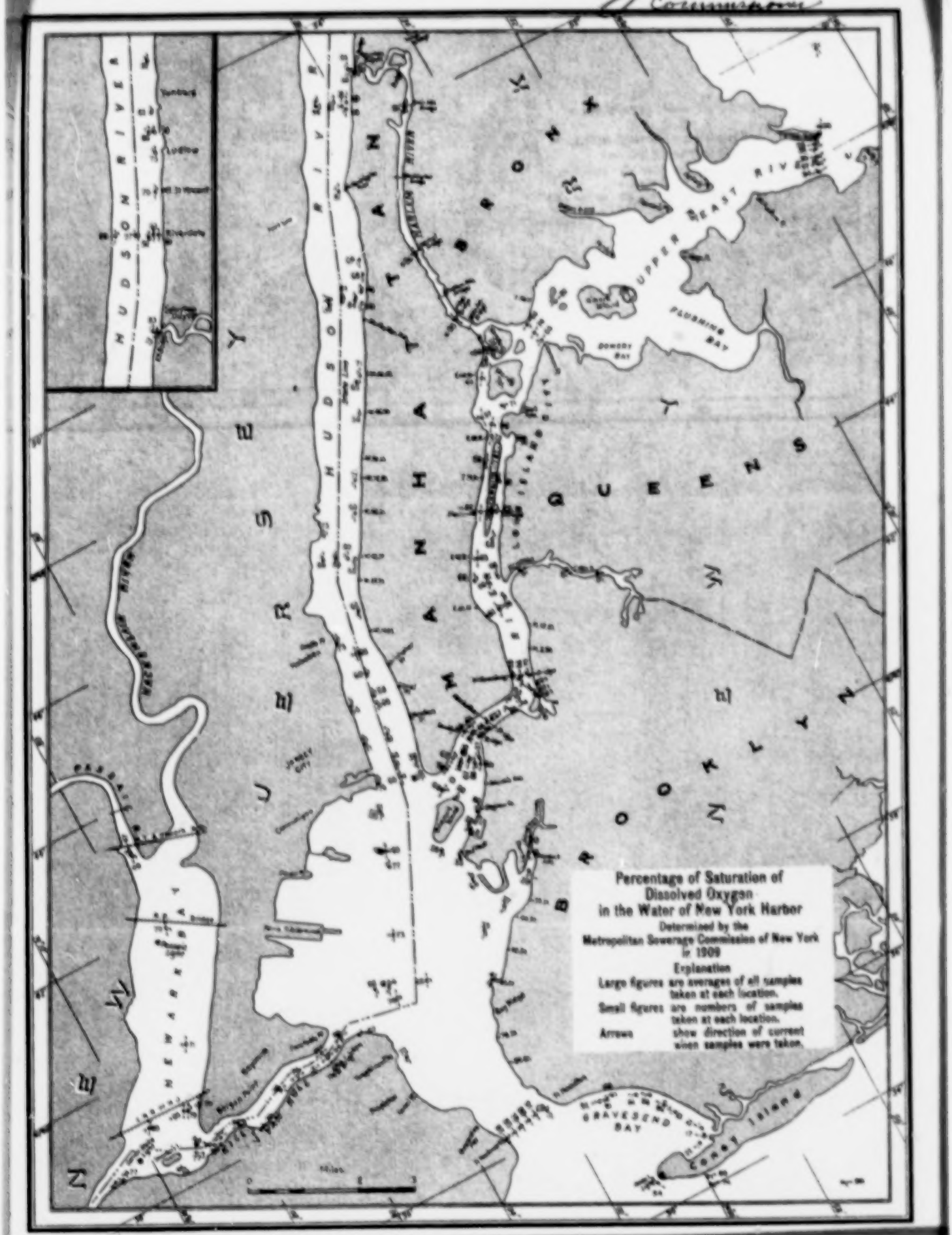
COMPLAINANTS' EXHIBITS Nos. 150, 151, 152, 153, 154, 155, and 156.

JAMES D. MAHER,
Commissioner.

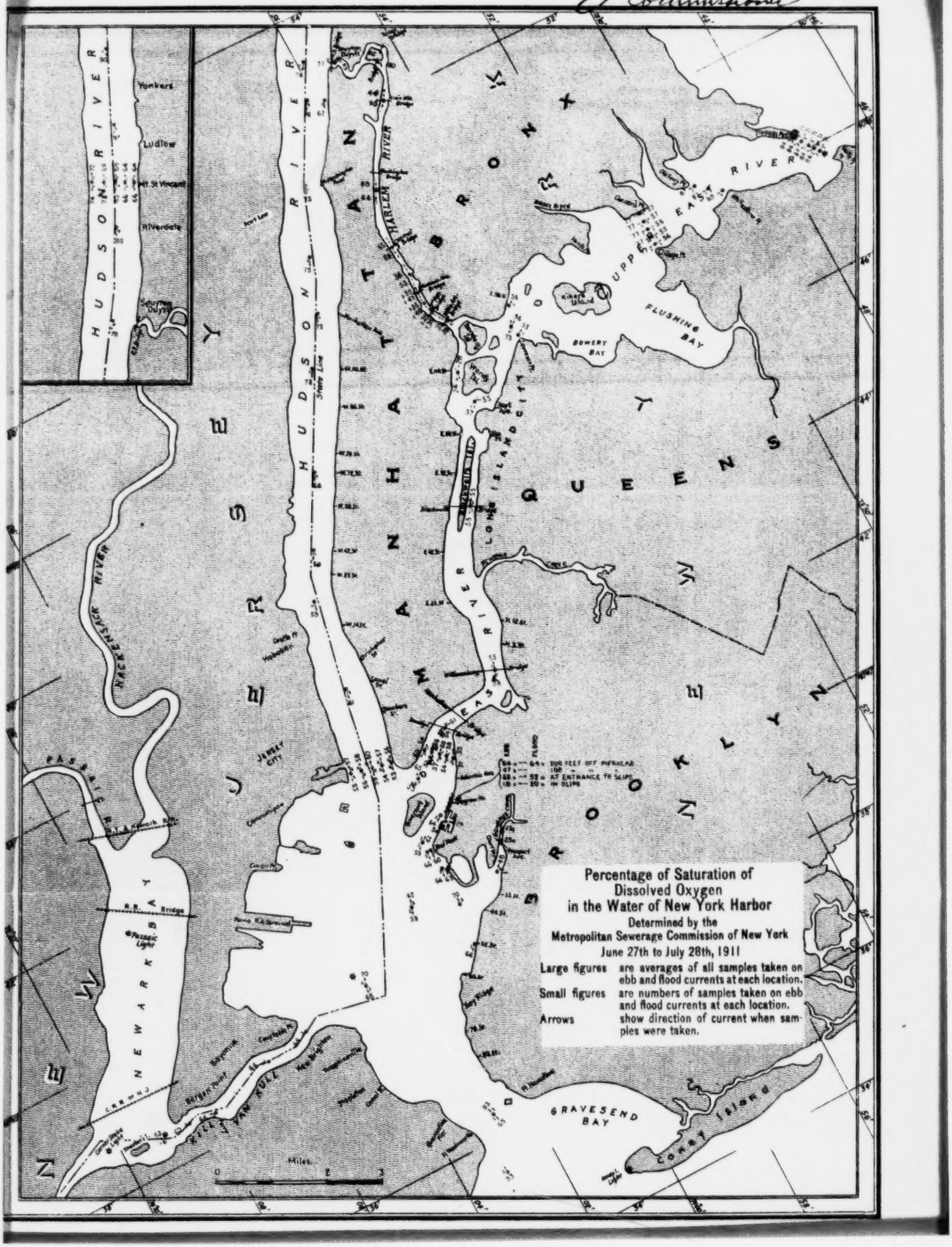
Complainants Exhibit No 150
Commissioners



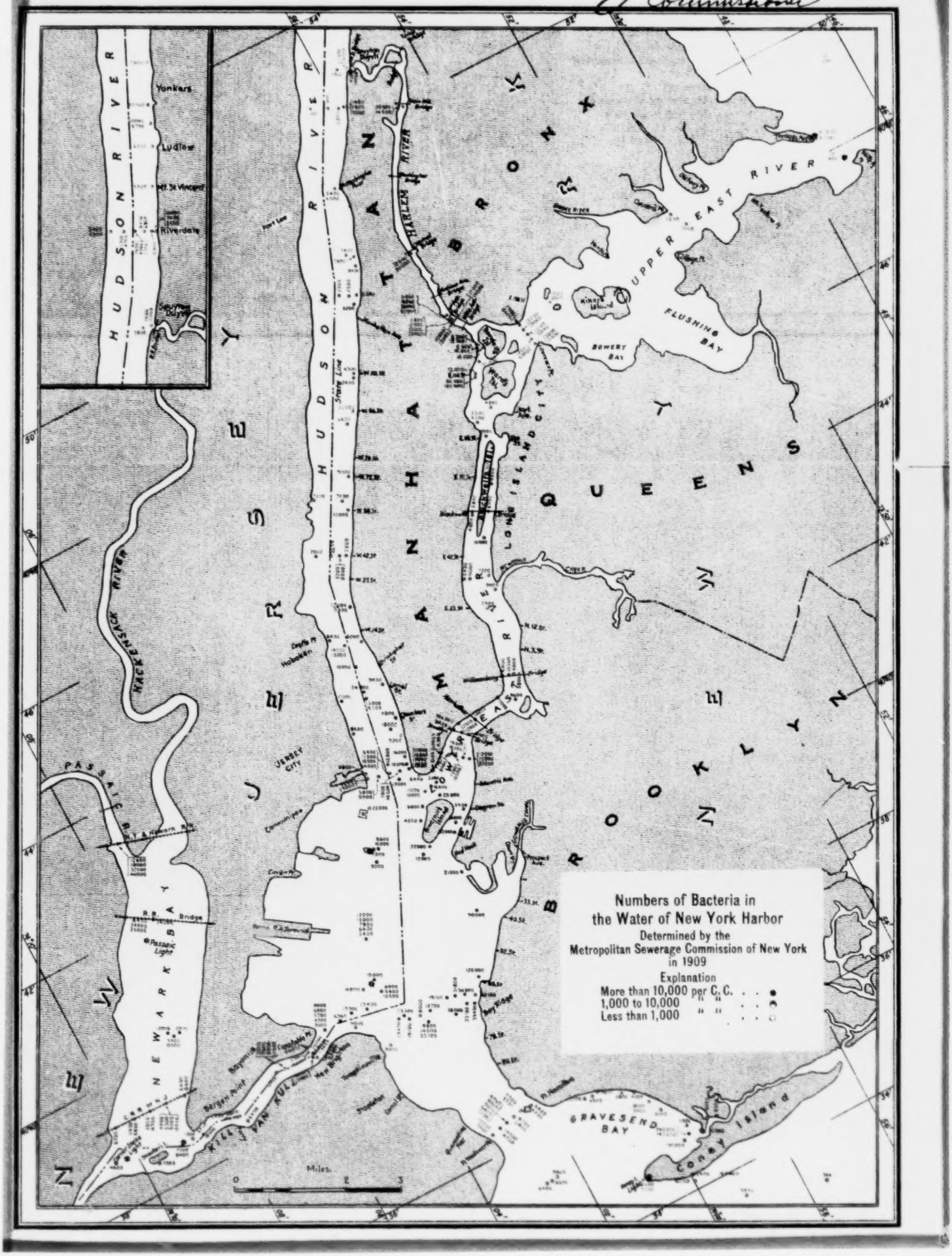
Complainant's Exhibit No 151
Jamieson
Commissioner



Complainants Exhibit No 152
James D Maher
Commissioner



Complainants Exhibit No 153
James D Maher
Commissioner

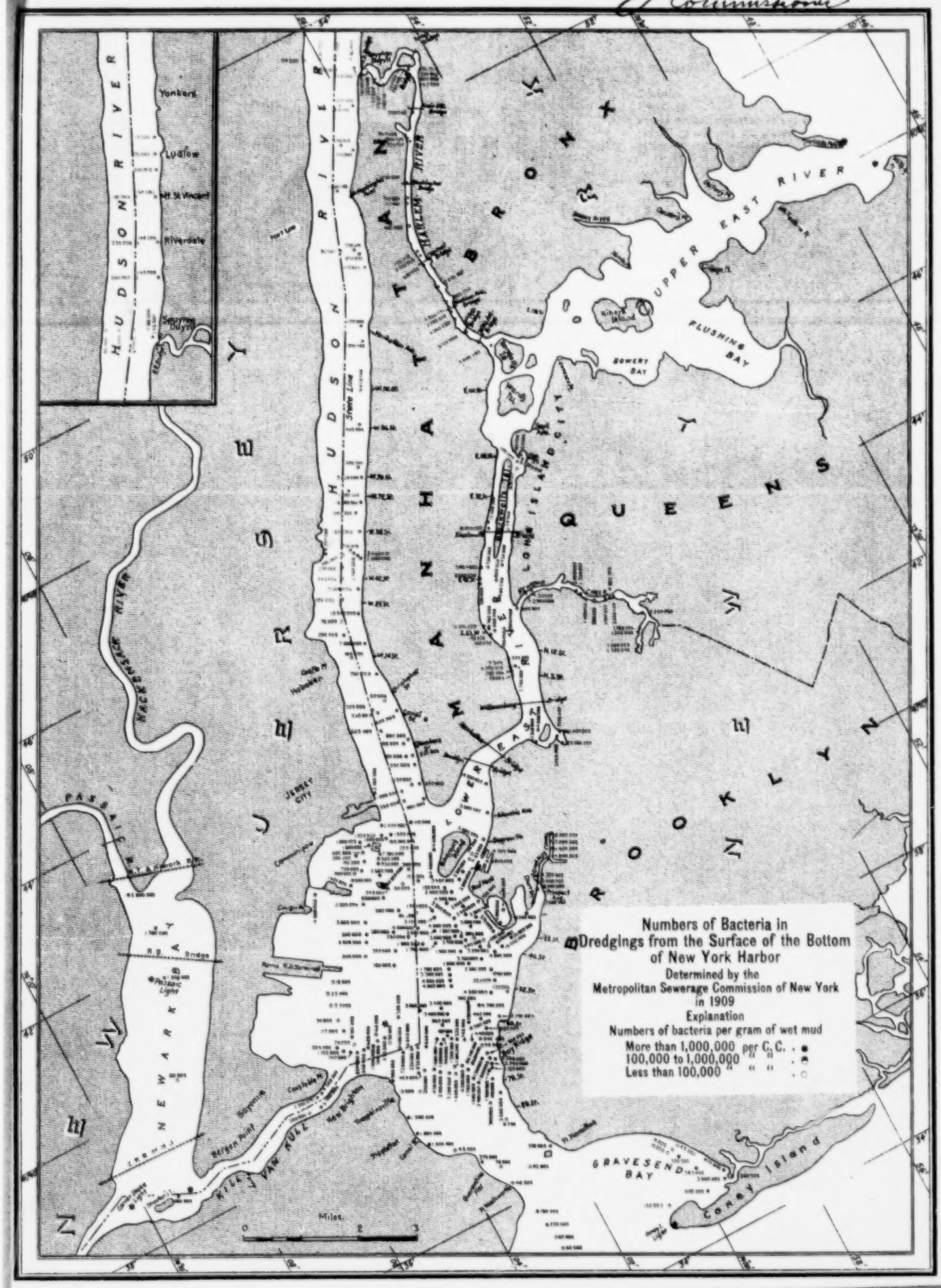


Numbers of Bacteria in
the Water of New York Harbor
Determined by the
Metropolitan Sewerage Commission of New York
in 1909

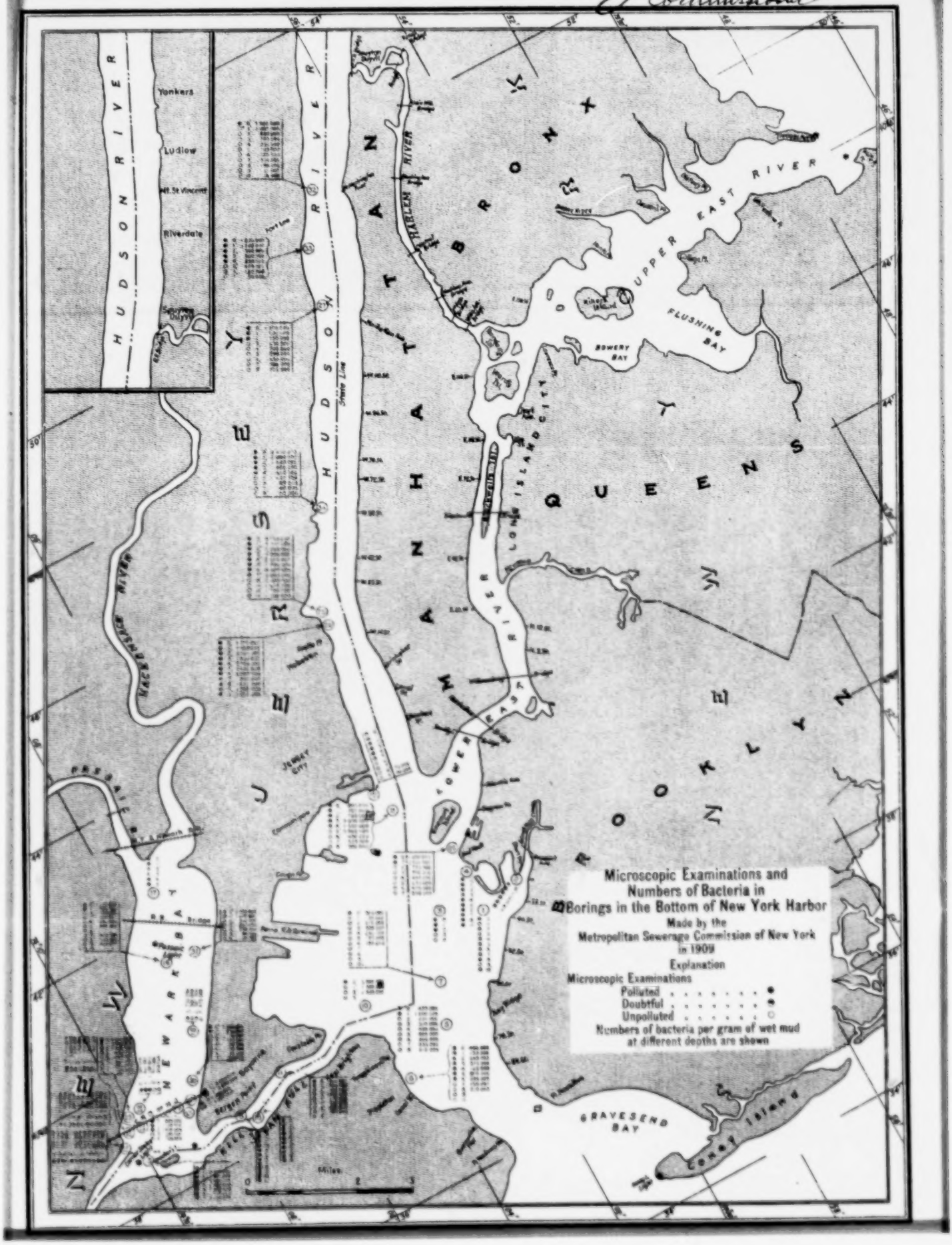
Explanation

More than 10,000 per C. C. . . ●
1,000 to 10,000 " " . . ◑
Less than 1,000 " " . . ○

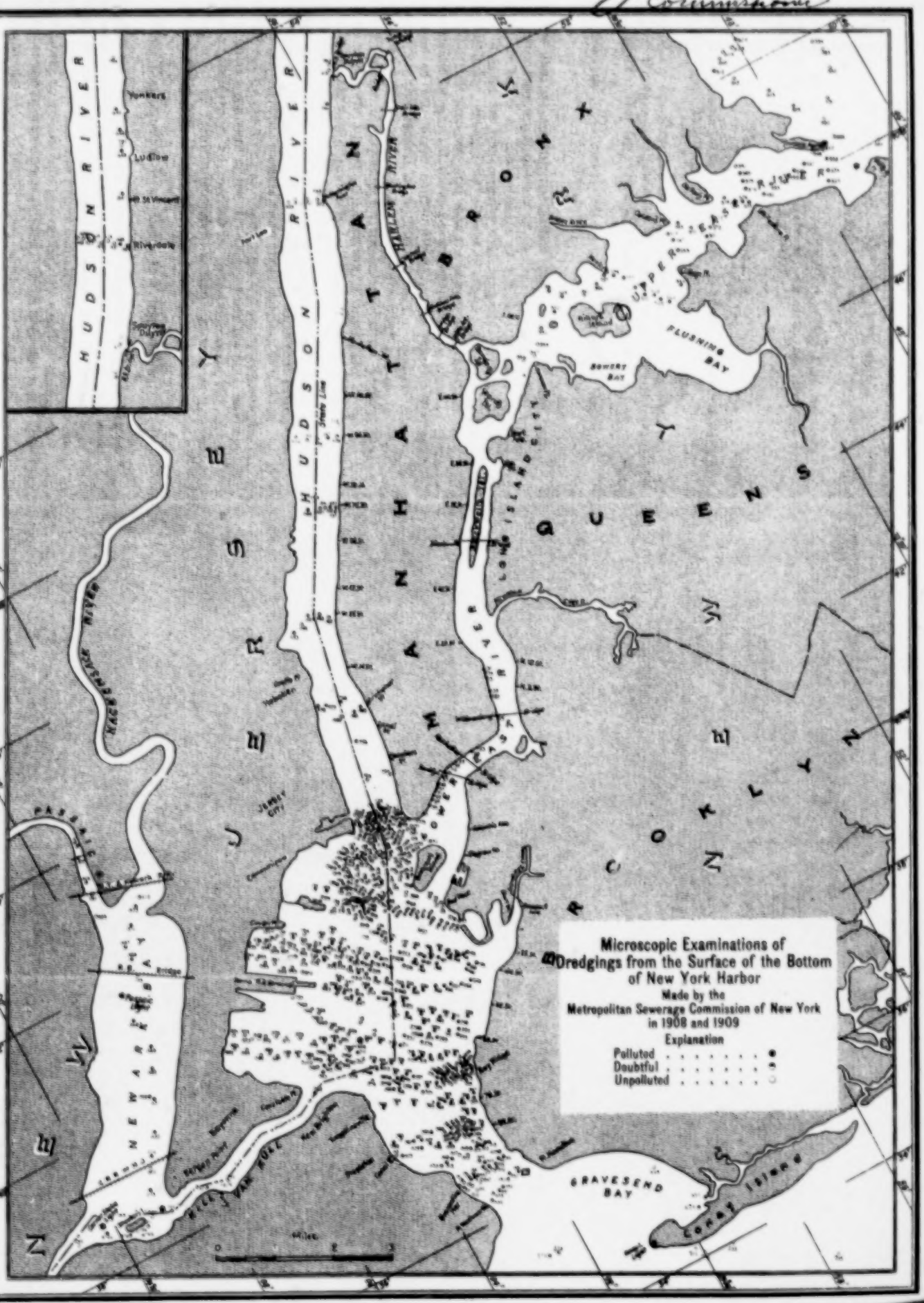
Complainants Exhibit No 154
James A Maher
Commissioner



Complainants Exhibit No 155
James D Maher
Commissioner



Complainants Exhibit No 156
Sewerage Commission



6 COMPLAINANT'S EXHIBIT No. 158. James D. Maher, Commissioner.

Report on the Estimate of the Central Committee that the Dry Weather Sewage Flow in the Metropolitan Sewerage District is Not Less than 125 Gals. Per Head Per Day.

February 6th, 1912.

John W. Alvord and Chas. B. Burdick, Hydraulic and Sanitary Engineers, Hartford Building Chicago.

1 *Report on the Estimate of the Central Committee that the Dry Weather Sewage Flow in the Metropolitan Sewerage District is Not Less than 125 Gals. Per Head Per Day.*

Volume of Sewage of Communities in the Metropolitan Sewerage District.

"Very few data concerning the actual discharge of sewage from the above named communities are available. Generally the water consumption is taken as the measure of the dry weather flow of sewage, but it must be remembered that appreciable quantities of water derived from independent sources of supply are used in most cities for industrial purposes, and that the sewers also receive a considerable amount of ground water by infiltration. In view of the fact that most of the larger communities in the District contain many industries, the central committee is of the opinion that a conservative estimate of dry weather flow of sewage is 125 gallons per head per day, on the average for the entire district, both at the present time and in the future. In arriving at this figure, it was assumed that measures would gradually be taken by most of the communities to check undue waste of water."

To satisfy myself that this estimate is conservative, I have made a careful study of the data which is available, and herein briefly review the conclusions which result from these studies, as follows:

As pointed out by the Central Committee, the water consumption is taken as a measure of the dry weather sewage flow, but that
2 this is considerably augmented by industrial waste, the water being supplied from independent sources, as well as infiltration of ground water into the sewer.

Water Consumption is an Index to Sewage Flow.

In the absence of continuous gaugings covering long periods of time, on sewered areas of known population, it becomes necessary to derive an estimate of the dry weather sewage flow by some other measure. It has often been the practice among engineers engaged in this line of work, to assume the per capita dry weather sewage flow equal to the per capita water consumption. This does not mean that

all the water supply is delivered to the sewer. There are a number of ways in which water may be used in such a way that it does not find its way to the sewer, among which are such uses of water as by steam railroads, some manufacturing and mechanical purposes, street and lawn sprinkling, etc.

At Milwaukee the Sewerage Commission in 1910 estimated the water which did not reach the sewer, as follows:

	Gallons per capita per day not reaching the sewer.
Steam railroads	5
Manufacturing and mechanical	5
Street sprinkling	5
Lawn sprinkling	2½
Consumers not connected to sewer	7½
Leakage from water mains & services	15
Total	40

3 This total of 40 gallons per capita represents about 38% of the total water supply. Probably considerable of the leakage from the mains and services finds its way to the sewer as ground water. The Commission assumed in making an estimate of the dry weather sewage flow that 35% of the water supply failed to reach the sewer.

Inasmuch as the water consumption is the principal factor determining the volume of the domestic sewage, I have prepared the following Table No. 1, giving the population and per capita water consumption of a number of cities. This table also gives the percentage of services that are metered, as this undoubtedly greatly influences the per capita consumption.

Table No. 2 gives the population of the various communities in the Metropolitan Sewerage District with the average water consumption at the present time in gallons per head per day for such communities where these data are available. The populations are as given in the 1910 U. S. Census.

From table No. 1 we find that in the seventy cities enumerated, the average consumption per capita daily to be 148 gallons. This average is determined by giving each city its relative weight in proportion to its population. This is done because in general the larger the city the larger the per capita consumption, and it is evi-

4 dent that the conditions in the larger cities are more nearly comparable with those in the Metropolitan District.

Considering Table No. 2, which is quite incomplete on account of the fact that the data pertaining to the water consumption in the various communities within the Metropolitan area is not available at this time, is probably the best index as to the average sewage flow to be expected from this area. From this table it appears that for the City of New York the average daily consumption of water per capita is 114 gallons. For the cities exclusive of the City of New

York, the average water consumption per capita is 111 gallons for the communities listed in Table No. 2, where the consumption is known. The total population of the communities in which the per capita water consumption is available, amounts to 5,998,342, of which, 4,937,243 reside in the City of New York. These data are therefore available for approximately 93.5% of the total population of the Metropolitan District which is 6,424,530, according to the U. S. Census for 1910.

Infiltration of Ground Water.

It is known that in a sewerage system, either sanitary or combined, the sewage flow is made up partially of ground water. This being caused by the ground water adjacent to the sewers, being at a higher level than the sewer, causing a seepage of this water through the joints into the sewer. The amount of this leakage into the sewer is most largely dependent on the pervious or impervious character of the soil. Aside from this factor, the elevation of the ground water level with reference to the sewer, and the perviousness of the sewer itself, are of importance. It is possible to somewhat reduce the amount of ground water leakage by care in construction, but from an economical standpoint, it is usually undesirable to build sewers so that the infiltration of ground water is completely prevented, as in most cases the lowering of the ground water is a valuable and important function of the sewer.

Actual measurements of the ground water flow are too meager to be of general value, and it is evident in any event, that it would be impracticable to determine the part of ground water in the sewers of the Metropolitan area by actual gaugings. It has been suggested that minimum flow during the night is practically equal to the ground water infiltration. This is probably very nearly the case in residential districts, although even here the flow caused by leakage from house fixtures, etc., would vitiate the above assumption. In districts containing industries using water throughout the twenty-four hours, no dependance could be placed on this method of obtaining measurement of the ground water leakage.

The amount of ground water entering the sewer is obviously independent of the population, and is usually expressed in gallons per acre per day, or gallons per mile of sewer per day. Expressing this flow in reference to miles of sewer is undoubtedly better than in reference to acreage, as the amount of seepage is undoubtedly proportional to the length of sewer laid, assuming that the local influencing condition is the same. To facilitate estimating the total flow in sewer districts, the unit gallons per head per day is usually used and for this reason it becomes necessary to express the ground water infiltration in this unit. It is possible to do this after the leakage per mile of sewer and the population on the area drained has been determined.

The Milwaukee Sewerage Commission recently had continuous gaugings covering a period of several days, made of a 72" sewer draining 358 acres of strictly residential portion of that city. Assuming the ground water infiltration equal to the minimum night

flow, it was found equivalent to 36,000 gallons per mile of sewer, 956 gallons per acre, or 31 gallons per capita. This sewer district is on comparatively high ground and the soil is of such a nature that the ground water infiltration is considerably less than in some of the lower portions of the city. The Commission came to the conclusion that the average leakage was 38 gallons per capita and the maximum rate was 76 gallons per capita.

7 From a study made of the data collected by the Engineers of the Metropolitan Sewerage Commission, Boston, relating to the flow in the North Metropolitan intercepting sewer, it is deduced that the ground water infiltration is equivalent to from 38.3 to 61.6 gallons per capita daily.

The following is a table showing the allowance made for ground water infiltration in various cities by engineers who have studied this matter.

Allowance Made for Ground-water Infiltration in Various Cities.

	Gals. per capita per day.			Gals. per acre per day.		
	Min.	Ave.	Max.	Min.	Ave.	Max.
Paterson, N. J. (Report of Joint Com. Sewage Disposal, '06, pp. 111)		14				
Louisville, H. P. Eddy		58				
Passaic Valley (Report Passaic Valley Sew. Com., 1908, p. 7)			29			
Milwaukee (Report Sewage Com., 1911)		38	76			
Neponset Intercepter, Boston (Report Met. Sew. Com., 1895, p. 38)			25			
High Level Sewer, Boston (Report Met. Sew. Com., 1899, p. 44)			24			
San Francisco (Grunsky's Report)	32*		97*	640		1,940
Indianapolis (Hering's Report, 1892)		25*			500	

* Computed from gals. per acre, assuming 20 people per acre.

8 From the table, and the observations cited hereinbefore, it is safe to assume that the ground water infiltration in a sewered area such as the Metropolitan Sewerage district, would average at least 25 gallons per capita per day.

Industrial Wastes.

No effort has been made to obtain complete information as to the quantity of industrial wastes discharged into sewers in the Metropolitan Sewerage District by industries obtaining their water from private sources. The only way to accurately determine the volume of industrial wastes in the Metropolitan area would be by a complete census of all the varied industries located within the district. This is probably at this time impracticable, and we must therefore, be satisfied with an estimate based on such data as *is* available.

In studying the question of industrial waste at Milwaukee, the Sewerage Commission adopted the allowance of 57 gallons per capita to cover a portion of the flow,—this amounting to 34.6% of the total sewage flow of 165 gallons per capita daily.

Sewage Flow Per Capita in Various Cities.

Records of gaugings of the dry weather flow in sewers are quite limited, especially gauges covering long periods of time. In table No. 3 I have tabulated such information on this subject which I have collected from various sources. Possibly the best records of sewer gaugings covering a long period of time, are those made by the Metropolitan Sewerage Commission at Boston. These records are fully discussed in the appendix No. 1 attached hereto, taken from the report made by the Milwaukee Sewerage Commission in 1911. It would be of no significance to average the various quantities in this table as some of these are simply single guagings, while others covered periods of various lengths, including several estimates recommended to be used in several cities by engineers after making a study of this question.

It will be seen from the table that there is a great variation in the flow to be expected, and that this variation is considerably greater than the variation in the water consumption in various communities as shown in Table No. 2, which would tend to show that in determining the average sewage flow, other sources of sewage besides the public water consumption must be taken into consideration.

Report of Metropolitan Sewerage Commission of New York.

The Metropolitan Sewerage Commission of New York in their report of 1910 commented on the volume of sewage discharged into New York Harbor, as follows:

"The volume of sewage produced in any district depends primarily on the water consumption, including that obtained from wells or other private supplies. In some towns, such as Paterson, these private supplies furnishing artesian water for manufacturing purposes, such as dye works, silk mills, rolling mills, breweries, etc., constitute an important proportion of the total amount of water used. If discharged into the sewers as is customary, it adds to the volume of the sewage, although it may not increase the total amount of the organic constituents of the sewage.

Aside from the water supply the flow of sewage may be materially increased by the infiltration of ground water through leaky sewers, or of surface waters through manhole covers. In the case of combined sewer the flow is enormously increased for short periods during storms.

On the other hand the volume of sewage carried by the sewers is diminshed, first, by the fact that suburban or rural areas are not provided with sewers, their liquid wastes going either to cesspools or on to the land; second, because in many instances manufacturing wastes are discharged directly to the nearest streams without passing through a sewer; third, by leakage from defective sewers into the soil, and fourth, on account of water used for street sprinkling and street cleaning purposes.

In a combination of towns such as is represented by those of the metropolitan district, it is believed a fair general estimate of the volume of sewage may be determined with the following assumptions:

1st. That the infiltration of surface and ground water to some sewers and the water used from private supplies will about offset that lost by leakage or by the ordinary direct disposal of streams and by street sprinkling.

2nd. That where an unusual discharge directly to streams is made from the mills, etc., due allowance to be made for this.

3rd. That the run-off directly due to storms be disregarded by assuming the dry-weather flow only of combined sewers.

4th. That districts without sewage facilities be omitted from consideration.

From these assumptions it follows that for the general purposes of this estimate the volume of sewage may be taken as equivalent to the water supply, corrected for any excessive discharge from other sources, or diversion to other outlets, by mills, etc.

11 In this way fluctuations due to non-resident population are accounted for without determining the number of people, the water supply being known."

Applying this method to the metropolitan district, this Commission prepared Table No. 4, setting forth the estimated sewage flow in 1910 and 1940. These estimates were made before U. S. Census — for 1910 were available and are therefore now subject to some correction, especially the forecast for 1940. Assuming the estimates for 1910 to be substantially correct, the total sewage flow for the Metropolitan district in 1910 amounts to 802 million gallons daily. The total population in 1910 according to the returns of the U. S. Census is 6,424,530, which amounts to a sewage flow of 125 gallons per head daily.

Conclusions.

That the estimate of an average sewage flow of 125 gallons per head per day for the Metropolitan district made by the Central Committee, both for the present time and in the future, is conservative, seems to be shown by practically all the data which I have collected on this subject. The estimate of the Metropolitan Sewerage Commission of New York shows present quantity amounting to 125 gallons per head daily and increasing considerably in the future.

12 The data relating to the water consumption amounting to 113 gallons per capita for 93.5% of the total population of the Metropolitan area would indicate that this will not be materially altered by the per capita consumption in the balance of the district. Assuming that 113 gallons represents the correct per capita water consumption daily and that due to reasons hereinbefore given, but 80% of this water actually reaches the sewers. This would amount to practically 90 gallons per capita. To this we must add an allowance for ground water infiltration which could be conservatively estimated at 25 gallons per capita. This would leave but 10 gallons per capita unaccounted for to take care of industrial waste, etc., the water being drawn from private sources.

The estimate of the Central Committee of 125 gallons of sewage per head per day is therefore conservative, and in my opinion, it is too low rather than too high.

13

TABLE No. 1.

Population & Water Consumption Per Capita Daily in Various Cities.

	Population. 1910.	Water consumption per capita daily.	Per cent metered.
1. Chicago	2,185,283	232	5.9%
2. Philadelphia	1,549,008	203	.6%
3. St. Louis	687,029	110	6.6%
4. Detroit	484,689	177	10.
5. Buffalo	423,715	314	4.3
6. Milwaukee	373,857	114	98
7. Washington, D. C.	331,069	75	29
8. Toronto, Ont.	395,000	89	4
9. Minneapolis	301,408	74	81
10. Jersey City, N. J.	267,779	150	8.7
11. Indianapolis	248,000	71	11.1
12. Kansas City	248,381	90	45.
13. Louisville, Ky.	223,928	99	8
14. St. Paul, Minn.	214,744	61	517
15. Portland, Ore.	207,214	83	30.1
16. Columbus	181,511	75.6	91.3
17. Toledo	168,497	93	80
18. Atlanta, Ga.	154,839	195	100
19. Worcester, Mass.	145,986	73	96
20. Schenectady, N. Y.	137,249	74	...
21. Memphis	131,105	103	45%
22. Richmond, Va.	127,628	96	68
23. Grand Rapids	112,571	142	42
24. Nashville, Tenn.	110,364	118	65
25. Cambridge, Mass.	104,839	99	30
26. Hartford, Conn.	103,329	75	100
27. Albany, N. Y.	100,253	223	23
28. New Bedford, Mass.	96,653	81	48
29. Pawtucket	96,191	66	86
30. Reading	96,071	129	15
31. Springfield, Mass.	88,926	119	61
32. Wilmington	87,400	118	34.3
33. Des Moines, Ia.	86,368	58.5	96
34. Lawrence, Mass.	85,892	45	91
35. Yonkers, N. Y.	79,803	103	100
36. Duluth	78,466	87.6	51.5
37. Houston, Texas	78,800	100	76
38. Manchester, N. H.	70,063	50	74
39. Erie, Pa.	66,525	207	2

TABLE No. 1—(Cont'd).

	Population. 1910.	Water consumption per capita daily.	Per cent metered.
40. Brockton, Mass.	64,170	39	100%
41. Holyoke, Mass.	57,730	102	9.
42. Jacksonville, Fla.	57,699	76.4	75%
43. South Bend, Ind.	53,884	88	18
44. Allentown, Pa.	51,913	138	.8
45. Springfield, Ill.	51,678	105	37.6
46. London, Ont.	50,000	116	7.4
47. Saginaw, Mich.	50,510	189	6
48. Binghamton, N. Y.	48,443	139.5	30
49. Rockford, Ill.	45,501	79	43
50. Haverhill, Mass.	44.115	72	17
51. Lincoln, Neb.	43,973	60	...
52. Davenport, Ia.	43,028	95	57
53. Macon, Ga.	40,662	100	26
54. Newtown, Mass.	39,806	65	89
55. Dubuque, Ia.	39,494	65	...
56. Kalamazoo, Mich.	39,437	49	100
57. Flint, Mich.	38,560	126	26
58. Quincy, Ill.	36,587	55	60
59. Lexington, Ky.	35,090	54	99
60. Auburn, N. Y.	34,668	179	10
61. Aurora, Ill.	29,807	67	86
62. East Orange, N. J.	29,630	100	10
63. Poughkeepsie, N. Y.	27,936	83.2	98
64. Waltham	27,834	88	.12
65. Lewistown, Me.	26,247	158	8
66. Madison	25,531	93	100
67. Cumberland, Md.	21,839	264	...
68. Port Huron, Mich.	18,863	375	7
69. Streator	14,253	139	9.1
70. Holland, Mich.	10,497	80	100

Weighted Average (pumpage per capita $= \frac{1,765,600,000}{11,926,400}$)

148.0 gals. per capita daily.

15

TABLE No. 2.

Population & Per Capita Water Consumption for Various Communities.

Metropolitan Sewerage District.

State of New York:

	U. S. Census, 1910.	Water consumption, gals. per capita daily.
Manhattan	2,331,542	131
The Bronx	430,980	93
Brooklyn	1,634,351	98
Queens	284,041	102
Richmond	85,969	93
City of New York (Total)	4,766,883	114
Westchester and Nassau Counties:		
Yonkers	79,803	103
White Plains	15,045	
Searsdale	1,300	
Tuckahoe	2,722	
Bronxville	1,863	
Mt. Vernon	30,919	100
New Rochelle	28,867	
Pelham	2,998	
Great Neck Landing & part of Great Neck	1,783	
Not included in above	5,060	
	170,360	
Total in State of New York	4,937,243	
State of New Jersey:		
Bergen County:		
Outside of Passaic Valley:		
Fairview	2,441	
Ridgefield	986	
Cliffside Park	3,394	
Palisade Park	1,411	
Leonia	1,486	

16 TABLE No. 2.—(Cont'd).

State of New Jersey (Cont'd):
Bergen County (Cont'd):
Outside of Passaic Valley (Cont'd):

	U. S. Census, 1910.	Water consumption, gals. per capita daily.
Englewood	9,924	
Teaneck	2,082	
Bogota	1,125	
Overpeck	4,512	
New Barbadoes	14,050	
Maywood	889	
Lodi Township	693	
Hasbrouck Heights	849	
Little Ferry	2,541	
Woodridge	681	
Carlstadt	1,964	
E. Rutherford	2,249	
Rutherford	3,663	
Union Twp.	2,038	
North Arlington	218	
Edgewater, Fort Lee and Englewood Cliffs	5,879	
Total outside Passaic Valley...	63,055	
Inside of Passaic Valley:		
Glen Rock	1,055	
Saddle River	3,047	
Midland	303	
Garfield	10,213	
Lodi Borough	4,138	
Hasbrouck Heights	1,306	
Woodridge	362	
Wallington	3,448	
Carlstadt	1,843	
East Rutherford	2,026	
Rutherford	3,382	
Union	2,038	
North Arlington	219	
Total inside Passaic Valley...	33,380	

17 TABLE No. 2—(Cont'd).

State of New Jersey (Cont'd):

Essex County:

Outside of Passaic Valley:

	U. S. Census, 1910.	Water consumption, gals. per capita daily.
Irvington	11,877	
South Orange	6,014	
West Orange	10,980	
South Orange	2,979	
Not included in above	5,477	
Total outside Passaic Valley	37,327	
Inside of Passaic Valley:		
Newark City (99%)	343,994	98
Orange "	29,630	
E. Orange	34,371	
Bloomfield	15,070	
Belleville	9,891	
Montclair	21,550	
Nutley & Glen Ridge	9,269	
Total inside Passaic Valley	463,775	

Hudson County:

Outside of Passaic Valley:

Bayonne	55,545	
Jersey City	267,779	150
Hoboken	70,324	114
West Hoboken	35,403	
Union	21,023	
West New York	13,560	
Weehawken	11,228	
North Bergen	15,662	
Not included in above	10,387	
Total outside Passaic Valley	500,911	
Inside of Passaic Valley:		
Harrison	14,498	124
East Newark	3,163	
Kearney	18,659	102
Total inside Passaic Valley	36,320	

18 TABLE No. 2—(Cont'd).

State of New Jersey (Cont'd):
Passaic County:
Inside of Passaic Valley:

	U. S. Census, 1910.	Water consumption, gals. per capita daily.
Patterson City	125,600	80
Passaic "	54,773	79
Acquackononk	11,869	
Manchester, Prospect Park and Hawthorne	8,679	
Total inside Passaic Valley	200,921	
Middlesex County: Outside of Passaic Valley:		
Roosevelt	5,786	
Woodbridge	8,948	
Perth Amboy	32,121	
Total	43,171*	
Union County: Outside of Passaic Valley:		
Elizabeth	73,409	82
Rosselle Park	3,138	
Millburn	3,720	
Summit	7,500	
Union Township	3,419	
Rahway	9,337	
Cranford	3,641	
Garwood	1,118	
Not included in above	3,145	
Total outside Passaic Valley	108,427	
Total in State of New Jersey:		
Inside of Passaic Valley	734,396	
Outside of Passaic Valley	752,891	
Total	1,487,287	
Total in Metropolitan District	6,424,530	

(* Adds to 46,855 see page 6a and 11 of Basic Physical Data.)

TABLE No. 3.

Gaugings of Dry Weather Flow of Sewers.

	Location.	Population.			Sewage Flow.		
		Date.	Total.	Tritbutary.	Min.	Ave.	Max.
1.	Compton Ave., St. Louis	1880	8,200	.....	65	102	149
2.	College St., Burlington, Vt.	1880	.....	325	65	115	140
3.	Huron St., Milwaukee, Wis.	1890	4,626	3,175	..	...	120
4.	Memphis, Tenn.	1881	3,500	20,000	61	...	140
5.	13 Sewers, Providence, R. I.	1884	.....	33,825	..	78	...
6.	16 " Toronto, Can.	1891	.....	168,081	..	87	...
7.	Des Moines, Ia., E. Side	1895	13,100	3,100	22.5	74	142
8.	" " " W. "	1895	28,000	19,400	23.2	66	175.3
9.	Schenectady, N. Y.	1892	.....	10,000	72	86	103.0
10.	Canton, O.	1893	.....	40,000	54	129	180.0
11.	Chautauqua	1894	.....	7,000	6	20	30.0
12.	Chicago:						
	Diversey Blvd. (W)	1911	23,550	.....	..	238	...
	Randolph St. (W)	1911	11,368	.....	..	348	...
	Robey St. (S)	1911	38,728	.....	..	169	...
	Ashland Ave. (S)	1911	44,581	.....	..	338	...
	Center Ave. (S)	1911	23,463	.....	..	578	...
	39th St. Pumping Station	1900	285,900	.....	..	•318	...
	" " " "	1900	285,900	.....	..	••227	...
	92nd St. Sewer	....	3,606	.....	..	325	...
	Wentworth Ave. (S) Calumet	....	30,464	.....	..	264	...
13.	North Metropolitan Sewer District	1904–'09	490,000	.....	..	120	...
14.	San Francisco (Estimated in Grunsky Report) (without ground water)	....	.....	.....	..	70	...
15.	Indianapolis (Rudolph Hering Report, 1892 (Est.)	....	.....	.....	..	90	...
16.	Worcester	1904	132,000	.....	..	118	...

TABLE No. 3.—(Continued).

Gaugings of Dry Weather Flow of Sewers.

Location.	Population. Date.	Total.	Tributary.	Sewage Flow. Min.	Avr.	Max.
17. London—Report of Maurice Fitzmorris.....	1901	5,136,000	.....	..	55	...
18. Milwaukee, Gaugings, Oct. 24-28—72" sewer.	1910	11,000	.....	31	83.5	207
19. Milwaukee Est. of Sewage Commission.....	1911	373,857	.....	..	105	...
20. Calumet District, Chicago (Est. Hering & Fuller)	1908	.....	.....	..	130	...

References:
1-7. Eng. News, pp. 132, Vol. XXXV; also Ogden sewer design.
9-10-11. Ogden sewer design, pp. 113.
12. G. M. Wisner.—Report on Sewage Disposal—San. Dis. Chicago—Oct. 12, 1911.
16. Eng. Record—Apr. 23, 1904—pp. 529.

* This run-off or more 76 days in 1909.
** This run-off or more 276 days in 1909.

TABLE No. 4.

Volumes of Sewage Produced in the Metropolitan District.

	Million gallons per day. 1910.	1940
New York State:		
Manhattan	343	650
The Bronx	45	195
Brooklyn	160	560
Queens	27	145
Richmond	8	30
The City of New York	583[1]	1,580.0
Mt. Vernon	3[2]	9.7
New Rochelle	1[2]	3.2
Yonkers	9[2]	27.4
Bronx Valley	3[3]	9.1
	599	1,629.4
New Jersey, Bergen County:		
New Barbadoes (Hackensack)	1.0[4]	1.4[4]
Passaic Valley sewer district	5.7[4]	41.3[5]
Balance of Bergen County in metropolitan district	...	3.7[4]
Union County:		
Elizabeth	6.0[6]	21.8[4]
Rahway	1.0[4]	.8[4]
Westfield and Cranford	1.0[4]	2.0[4]
Joint outlet sewer	8.0[7]	13.9[4]
Essex County, Passaic Valley sewer district:		
Newark	52.0[4]	93.7[4]
Orange	4.5[4]	10.8[4]
East Orange	4.1[4]	12.1[4]
Balance of Passaic valley district in Essex County	14.7[4]	42.4[4]

[1] Based on the consumption of water. [2] Eng. News, Apr. 29, 1909. [3] N. Y. State Bd. Hlth., 1907. [4] U. S. Census Bul., 105, 1907. [5] Letter G. R. Byrne, Ch. Engr., May 5, 1909. [6] Rep. Passaic Valley Sewerage Com., 1908. [7] Letter from Alexander Potter, Nov. 16, 1908.

21

TABLE No. 4. (Cont'd).

Volumes of Sewage Produced in the Metropolitan District.

		Million gallons per day.
New Jersey, Hudson County:		
Jersey City	39[2]	54.4[2]
Hoboken	8[2]	12.9[2]
Bayonne	4.3[2]	22.0[2]
West Hoboken	1[2]	13.4[2]
Union	2[2]	5.1[2]
North Bergen	1.5[2]	3.1[2]
Weehawken	1[2]	5.7[2]
West New York	1[2]	3.4[2]
Passaic valley sewer district:		
Kearney	1.9[1]	12.9[2]
Harrison	1.8[1]	8.2[2]
East Newark	.6[1]	1.2[2]
Miscellaneous	....	3.2[2]
Middlesex County:		
Perth Amboy	3.5[2]	14.0[2]
Woodbridge	....	1.7[2]
Passaic County, Passaic valley sewer district:		
Paterson	31[1]	64.8[1]
Passaic	4[2]	28.1[1]
Balance of Passaic valley sewer district in Passaic County	4.4[1]	17.1[1]
	203	515.2
Total for Metropolitan District	802.0*	2,144.6

[1] Rep. Passaic Valley Sewerage Com., 1908.
[2] Based on the consumption of water.
[3] U. S. Census Bul., 105, 1907.
*Total in original report was 741.—was probably a typographical error.

22 APPENDIX No. 1.

Extracts from Report of the Milwaukee Sewage Commission on the Quantity of Sewage Likely to be Produced.

April 25th, 1911.

By John W. Alvord, Geo. C. Whipple, Harrison P. Eddy, Commission.

23 Recommendation of Commission as to Quantity of Sewage to be Provided for: The average volume of sewage at the present time is estimated to be 61,000,000 gallons per day. Guided by the estimated future population and area, and a study of the water consumption and its probable increase, the amount of water likely to be used for manufacturing, and the amount of ground water leaking into the sewers, we have estimated that in 1930 the average daily volume of sewage for a considerable period of time each year, will be about 100,000,000 gallons, and in 1950, 155,000,000 gallons. The maximum rate of flow of sewage is now estimated to be about 107 million gallons daily, in 1930, 176 million gallons, and 265,000,000 gallons in 1950. The latter is equal 312 gallons per capita.

Data upon which Above Recommendation Was Made.

Actual Quantity of Water Supply Reaching Sewers.

As shown in detail in the consideration of the flow of sewage in the North Metropolitan intercepter in Boston, the quantity of sewage flowing in dry weather is frequently equivalent to not over ninety per cent of the water consumption. It cannot be reasoned from this fact however, that ninety per cent of the water supply is delivered to the sewer.

There are many ways in which water is used or lost without 24 finding its way to the sewers. Among these may be mentioned railroad uses, water used for steam purposes, street and lawn sprinkling, that supplied to buildings not connected with sewers, and, probably the largest item of all, leakage from the water mains and services. The losses from these sources may be estimated as follows, based upon an assumed supply in Milwaukee in 1910 of 105 gallons per capita per day:

TABLE 18.

Estimated Quantities of Water Furnished by Water Works which do Not Reach the Sewers.

Milwaukee, 1910.

	Gals. per capita per day.
Steam railroads	5
Manufacturing and Mechanical purposes	5
Street Sprinkling	5
Lawn Sprinkling	2½
Consumers not connected with sewers	7½
Leakage from mains and services	15
Total	40

The total of these losses (40 gallons per capita per day) is equivalent to slightly over 38% of the supply. This estimate is based upon fragmentary and, in some cases, unsatisfactory information, but it seems reasonable to assume that at least 35% of the water supply will fail to reach the sewers by way of the house drains.

It should be mentioned in passing, that the leakage from the water mains and services tends to increase the supply of ground water, and that doubtless much of this water may eventually find its way into the sewers in the form of leakage.

25 The quantity of the municipal water supply estimated to reach the sewers, is therefore in round numbers as follows:

TABLE 19.

Estimated Quantity of Municipal Water Supply which Will Reach the Sewers.

1910	70	gals.	per	capita	per day.
1920	72½	"	"	"	"
1930	75	"	"	"	"
1940	80	"	"	"	"
1950	85	"	"	"	"

Ground Water.

As indicated by the name, this classification includes such waters as find their way by means of leakage from the ground into the sewers. It is also intended to include such surface water as leaks through perforated manhole covers and defective brickwork in manholes, and the surface water which flows during comparatively dry weather and after the run-off ordinarily considered as storm water has ceased to flow, in small natural brooks necessarily connected with a sewer system built upon the combined plan.

While a large proportion,—probably in Milwaukee from 50 to 75

per cent.—of the rainfall runs off into the sewers very quickly after it has fallen, and is therefore properly called storm water, the remainder slowly percolates into the ground and supplies the natural underground streams, and is here referred to as ground water.

Sewers are often necessarily built at such a depth as to lie
26 below the natural surface of such waters, and if they are not perfectly tight,—condition almost impossible to obtain,—there is more or less leakage into the pipes, with a consequent lowering of the ground water level.

Another source of ground water is the filtration from the rivers into the land lying near them. It is quite possible, in a city located like Milwaukee, that more or less of such water will find its way into the sewers lying comparatively near to the rivers.

The natural ground water (not the water filtering from the rivers) varies in elevation from season to season. During the spring when the frost is coming out of the ground and leaving the soil porous, so that the rain and melting snow can penetrate it easily, the supply of ground water is greatly increased, and the elevation of the water table usually rises several feet. As this water flows away through natural channels, or finds its way by infiltration into the sewer system, the elevation of the ground water is gradually reduced, and as this reduction takes place, there is less head upon the sewers and the quantity of infiltration becomes gradually less and less, until if the supply is not replenished, the quantity of leakage from this source may be reduced to nil. It is also true that the elevation of ground water varies from year to year with the quantity and distribution of rainfall.

27 The sewers first built in a district usually follow in a general way the natural water courses, and therefore lie in the bottoms of the valleys. Such sewers are often, especially in case of combined systems, built very close to, or actually in the natural beds of brooks. They are not usually extended to the extreme upper end of the district at first, and consequently the natural run-off through these brooks is taken into the sewers. Such brooks frequently flow, with gradually diminishing volume, for many days after the immediate run-off from a storm has passed by, and perhaps even throughout the dry season. The flow during the remainder of the time, until the next storm, is made up of the water draining out of the land, and is therefore logically classed with ground water, and, as its flow is continuous though gradually diminishing, it has the same effect upon the quantity of sewage. As a result of these conditions, such sewers receive comparatively large quantities of ground water, while it is but natural to expect that sewers built in these districts in later years, necessarily at higher elevations, will receive smaller quantities of leakage and brook flow.

Many measurements have been made to determine the quantity of ground water which finds its way into sewer systems. The results of these observations, indicate that the quantity of infiltration may be as low, under the most favorable conditions, as 5,000 or
28 10,000 gallons per day per mile of sewer. On the other hand, they show that the leakage frequently amounts to from 20,000

to 40,000 gallons per day, and at times of very high ground water, or during rain when there is leakage through manhole covers, even in separate systems it may run as high as 100,000 gallons per day per mile of sewer. In fact, there are instances where the leakage has materially exceeded this quantity.

As a rule, there has been a growing tendency toward securing as nearly water-tight construction as possible, so that it is undoubtedly true that the older systems receive greater quantities of ground water than some of the better constructed modern systems.

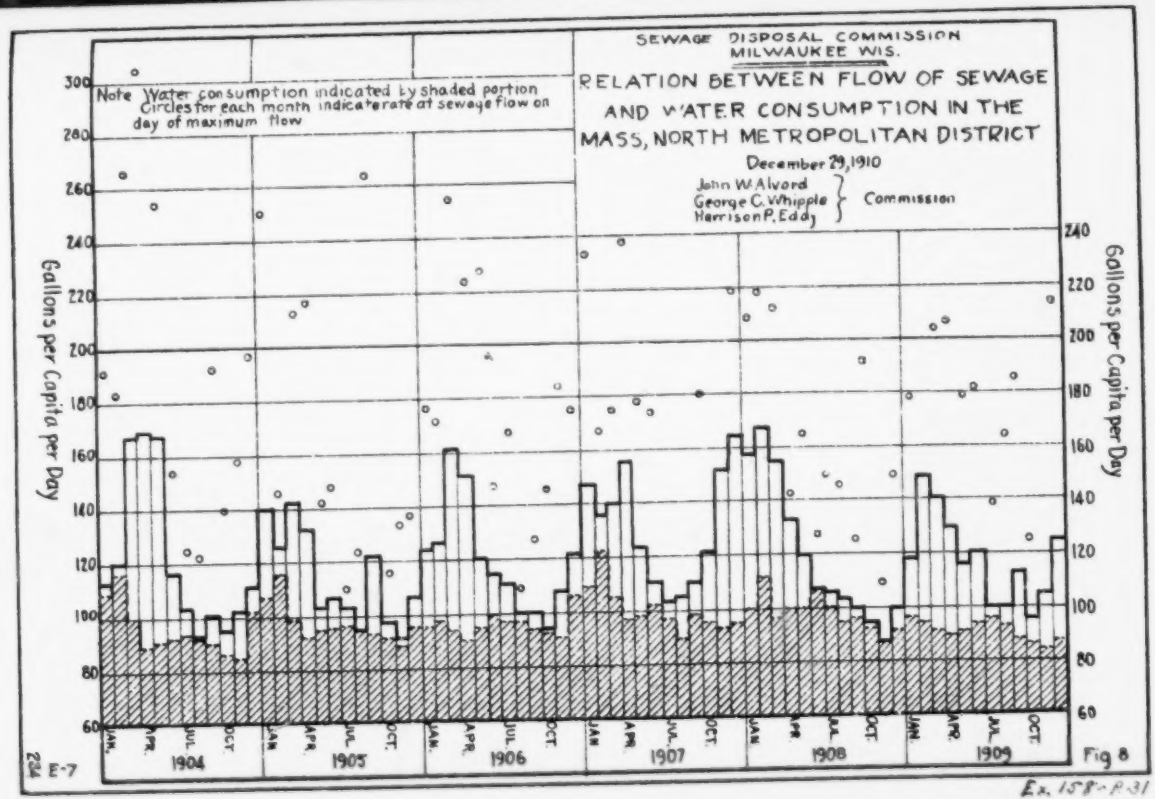
A Study of Records of Quantity of Sewage Delivered by the North Metropolitan Sewer, Boston, Mass.

Obviously, it has been impossible for us to obtain complete data regar-ing the quantity of sewage produced at Milwaukee, with observations of the rate of flow at different hours of the day, days of the week and seasons of the year. Such information can be collected only by continuous records extending over several years, and it is practicable to collect it only when the sewage is delivered to a single point instead of being discharged at many different points, as at Milwaukee. For this reason it has been deemed wise to make a study of such records collected in other places, and to apply
29 the lessons drawn from them to conditions at Milwaukee, giving proper weight to differences in local conditions.

The best data relating to the flow of sewage, available for study, appear to be those collected by the Engineers of the Metropolitan Sewerage Commission, Boston, Mass., who have practically continuous records extending back over many years. Our study has been confined, for the most part, to data relating to the North Metropolitan intercepting sewer. The district served includes 15 cities and towns, many of which are provided with the separate system of sewers. The cities of Cambridge, Everett, Chelsea and Somerville, and the Charlestown and East Boston districts in the City of Boston, which are served by this intercepter, are sewered upon the combined plan, and automatic regulators are provided at the sewer intersections, so that when the intercepting sewer is full, the gates are partially or wholly closed, and the surplus flow in the trunk sewers is discharged directly into the water courses or the harbor.

This sewer was designed to serve a territory of 46,000 acres, and a population of 571,000 in 1930. In 1909, the area served was 18,560 acres and the population 511,500.

Table 20 is a compilation of certain data based upon the entire population of the district tributary to this sewer, for the years 1904 to 1909 inclusive. The average quantities of sewage per day, per acre and per capita, (columns 3 and 4) are doubtless some-
30 what greater than if the storm water from the districts sewered on the combined plan was not received; but as those quantities represent the monthly averages, the error is probably not serious. On the other hand, there are overflows from the intercepter, which reli-ve it at times of excessive flow. Column 5 purports to be the maximum quantity per capita for a single day, but is obviously


SEWAGE DISPOSAL COMMISSION
MILWAUKEE WIS.
RELATION BETWEEN FLOW OF SEWAGE AND WATER CONSUMPTION IN THE MASS, NORTH METROPOLITAN DISTRICT
December 29, 1910
John W. Alvord
George C. Whipple
Harrison P. Eddy
Commission
Note Water consumption indicated by shaded portion
Circles for each month indicate rate of sewage flow on day of maximum flow
Gallons per Capita per Day
300
280
260
240
220
200
180
160
140
120
100
80
60
JAN.
APR.
JUL.
OCT.
1904
1905
1906
1907
1908
1909
234 E-7
Fig 8
Ex. 158-P-31

considerably lower than the actual quantity, if the sewer were ample to provide for the district as originally planned. On account of the tributary combined systems, these quantities are all more or less affected by storm water, although it is apparent that but little can be accommodated.

The yearly averages of the quantity of sewage and of the water consumption are given in Table 21, which also shows the relation between the average quantity of sewage and the average water consumption. Column 5 is made up of the percentage which the quantity of sewage is of the water consumption. It will be noted that this percentage varies from 115.7 to 128.7. It would seem to be a reasonably fair assumption for this district that the sewage flow would on an average be about 25% in excess of the quantity of water consumed.

(Here follows diagram, Fig. 8, marked page 31, Complainants' Exhibit 158.)

Fig. 8 shows graphically the relation between the average quantity of sewage and water consumption, as well as the maximum quantity of sewage for a single day. The shaded portion shows the quantity of water consumed. The shaded portion plus the unshaded portion below the heavy line, represents the quantity of sewage. The
32 small circles show the maximum quantity of sewage for a single day in each month.

33 TABLE 20.

Quantity of Sewage Discharged from North Metropolitan Sewer District, Boston, Mass.

(Calculations based on entire population of tributary district.)

Date.	Population.	Ave. quantity per acre per day.	Ave. quantity per capita per day.	Max. quantity per capita upon one day.	Min. quantity per capita upon one day.	Ave. water consumption per capita per day.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
1904.						
Jan.	470,635	3030	109.9	192.0	86.3	113.2
Feb.		3291	119.4	185.5	98.2	117.1
Mar.		4650	168.7	265.0	130.0	99.6
Apr.		4700	170.5	308.0	111.8	88.0
May		4645	168.5	253.0	128.8	91.0
June		3175	115.2	153.9	91.6	91.9
July		2825	102.4	123.5	86.7	94.2
Aug.		2575	93.5	122.8	77.8	91.9
Sept.		2781	100.9	190.9	79.2	91.2
Oct.		2630	95.4	138.7	79.3	86.7
Nov.		2830	102.6	158.5	90.5	85.7
Dec.		3045	110.5	197.0	95.4	102.0
1905.						
Jan.	478,800	3911	140.6	248.5	110.5	106.3
Feb.		3505	126.0	144.8	106.5	117.0
Mar.		3990	143.1	213.0	99.9	99.2
Apr.		3715	133.5	217.5	100.9	92.0
May		2875	103.3	141.3	91.5	96.1
June		2991	107.5	148.4	75.6	96.6
July		2700	97.0	111.1	86.9	102.7
Aug.		2620	94.0	122.5	79.0	94.6
Sept.		3421	123.0	264.5	94.9	94.1
Oct.		2705	97.1	115.7	82.1	92.2
Nov.		2561	91.9	134.1	71.3	80.7
Dec.		2975	107.0	136.9	88.4	96.2
1906.						
Jan.	486,965	3430	123.7	178.0	99.2	96.2
Feb.		3550	128.0	173.0	101.5	99.4
Mar.		4540	163.7	255.0	130.6	95.0
Apr.		4220	152.0	223.5	110.0	91.8
May		3315	119.6	229.0	93.3	96.4
June		3175	114.5	148.0	98.6	99.6
July		3090	111.5	168.3	87.9	97.7
Aug.		2684	98.8	110.4	81.8	100.0

Date.	Population.	Ave. quantity per acre per day.	Ave. quantity per capita per day.	Max. quantity per capita upon one day.	Min. quantity per capita upon one day.	Ave. water consumption per capita per day.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
		Gallons.	Gallons.	Gallons.	Gallons.	Gallons.
Sept.		2675	95.8	127.8	85.9	100.3
Oct.		2655	95.8	146.4	80.7	93.6
Nov.		2926	108.1	184.2	86.9	91.7
Dec.		3415	123.0	175.0	94.3	107.0
1907.						
Jan.	495,150	4055	148.3	242.0	122.8	111.6
Feb.		3705	137.7	168.0	115.1	123.0
Mar.		3855	141.0	174.8	115.7	106.0
Apr.		4285	156.7	237.5	120.2	97.8
May		3380	123.6	178.2	110.3	98.0
June		3020	110.5	174.8	86.0	102.0
July		2840	96.6	115.9	86.0	104.5
Aug.		2450	89.7	98.6	80.0	106.0
Sept.		3065	112.0	257.0	77.3	98.5
Oct.		3350	122.5	179.8	95.9	96.0
Nov.		4195	153.5	295.0	104.3	94.0
Dec.		4515	165.2	219.0	134.7	95.4
1908.						
Jan.	503,330	4345	158.2	208.5	117.0	101.0
Feb.		4050	169.3	218.0	129.8	113.0
Mar.		4235	154.3	213.0	127.5	97.6
Apr.		3660	133.4	141.1	119.8	100.0
May		3245	118.8	165.8	93.4	99.0
June		2946	107.3	128.1	95.4	107.5
July		2750	100.4	150.0	84.7	106.5
Aug.		2840	103.5	147.7	84.0	96.0
Sept.		2710	98.8	126.4	83.1	95.7
Oct.		2610	95.0	190.8	77.1	93.0
Nov.		2410	87.6	110.5	72.7	87.8
Dec.		2740	99.8	149.5	75.1	92.0
1909.						
Jan.	511,500	3285	119.0	179.5	89.7	98.0
Feb.		4155	150.5	270.0	93.5	96.4
Mar.		3915	141.9	203.0	113.5	91.9
Apr.		3575	129.5	206.5	108.7	91.1
May		3200	116.1	178.0	90.3	91.6
June		3330	120.8	181.3	86.8	95.5
July		2775	100.7	138.2	88.4	96.9
Aug.		2781	100.9	164.0	83.7	93.8
Sept.		3116	113.0	184.5	86.3	88.9
Oct.		2616	94.9	124.3	75.9	86.7
Nov.		2950	107.0	272.7	73.1	84.7
Dec.		3500	126.9	213.0	97.0	88.0

TABLE 21.

Relation of Quantity of Sewage to Water Consumption, North Metropolitan Sewer District, Boston, Mass.

(Based on total population of district.)

Year.	Precipitation, inches.	Avg. sewage flow, gals. per capita.	Avg. water consumption, gals. per cap.	Ratio sewage to water, %.
(1)	(2)	(3)	(4)	(5)
1904	42.82	121.5	96.0	126.6
1905	42.31	113.5	98.1	115.7
1906	44.48	119.4	97.4	122.6
1907	44.38	129.6	102.7	126.2
1908	36.15	119.0	99.2	120.0
1909	41.75	118.4	92.0	128.7
Average				123.3%

34 Similar data, based upon the number of people actually connected with the sewer system, Table 22, show a ratio of sewage flow to water consumption much higher than where the entire population is used as the basis of calculation. This ratio varies from 140 to 162%. In considering these figures, however, it should be borne in mind that those buildings and industries most needing sewers, and therefore first accom-odated, are usually the ones having the greatest quantity of wastes to dispose of. The outlying and scattered population, which is not supplied with sewage facilities, would probably not use as large a quantity of water, or have as large a quantity of sewage to be disposed of, as the denser population and the manufacturing and mercantile districts.

TABLE 22.

Relation of Quantity of Sewage to Water Consumption, North Metropolitan Sewer District, Boston, Mass.

(Based on number of persons connected with sewer system.)

Year.	Avg. sewage flow per capita, gals. per day.	Avg. water consumption per capita, gals. per day.	Sewage to water, %.
(1)	(2)	(3)	(4)
1904	156	96.0	162.5
1905	145	98.1	147.9
1906	151	97.4	155.0
1907	152	102.7	148.0
1908	139	99.2	140.1
1909	136	92.0	147.8

It is interesting to note that in spite of the fact that large tributary areas are provided with combined sewers the average
35 quantity of sewage seems to bear little or no relation to the average rainfall. This may be due in part to the small size of the intercepter, which has little capacity in excess of the requirements for fair weather and can therefore, carry only a very small quantity of storm water.

While the actual measurements of sewage are usually in excess of the measurements of water furnished to the same population, it should not be assumed that all of the water supplied to the community is delivered to the sewers. In fact, there are several days in the course of the year when the average sewage flow is actually less than the water supply. In January, 1904, August, 1905, August and September, 1906, August and July, 1907, and November, 1908, the average flow of sewage for the entire month was less than the average quantity of water supplied to the tributary population.

The sewage of a community is made up not only of the water received from the water supply, but also of ground water leaking into the sewers, storm water leaking through manhole covers, industrial and mercantile wastes, (the supply for which is obtained from sources other than the municipal supply), and storm water, where the sewers are built to receive storm water as well as sewage. It not infrequently happens in districts provided with separate sewers, that connections are made, with or without authority, through which roof water, and sometimes the drainage of areas is admitted.

An effort has been made to estimate the average quantity
36 of sewage flowing in the North Metropolitan Intercepter, exclusive of storm water, for certain months during which the rainfall was low, and in which the ground water also might be expected to be low. To aid in these studies, Fig. 9 has been prepared. The solid line represents the actual recorded quantity of sewage pumped, while the dotted lines indicate the estimated quantity of sewage excluding the storm water. By eliminating the quantities above the dotted lines, an approximation has been made of the average flow of sewage, exclusive of the run-off from storms. In the case of September, 1906, this quantity amounted to 44.8 million gallons per day. The water consumption for the same period of time was 48.8 million gallons per day. The quantity of sewage was therefore 91.9% of the quantity of water supplied to the community. Similar computations were made for six other dry months, with the results given in Table 23.

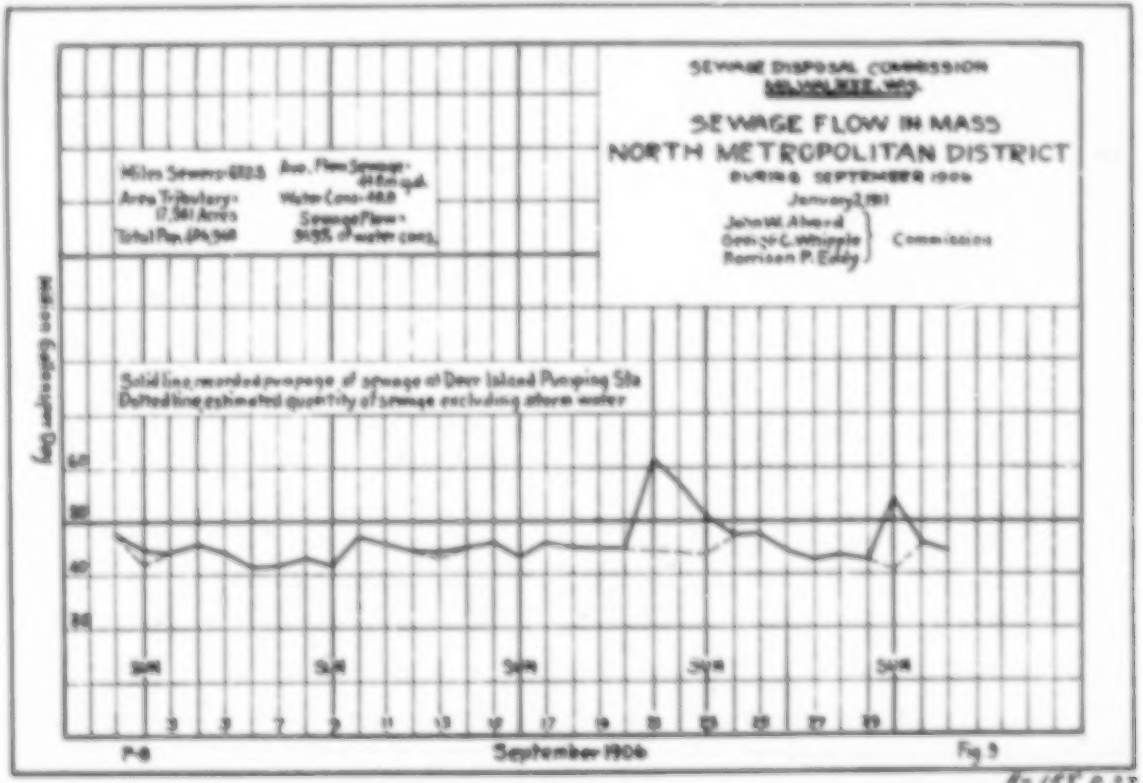
Table 23.

Ratio of Sewage Flow to Water Consumption During Dry Weather.

(North Metropolitan Sewer District, Boston, Mass.)

Date. (1)		Relation of sewage flow to water consumption. (2)
August,	1904	98.1%
"	1905	95.8
"	1906	94.3
Sept.,	1906	91.9
"	1908	100.9
Oct.,	1908	93.7
Nov.,	1908	98.0

(Here follows diagram, Fig. 9, marked page 37, Complainants' Exhibit 158.)


SEWERAGE DISPOSAL COMMISSION
SEWAGE FLOW IN MASS
NORTH METROPOLITAN DISTRICT
DURING SEPTEMBER 1906
January 2, 1901
John W. Alvord
Geo. C. Whipple
Harrison P. Eddy
Commission
Miles Sewers-62.0
Area Tributary-17,561 Acres
Total Pop. 694,368
Ave. Flow Sewage-44.8 m.g.d.
Water Cons.-48.0
Sewage Flow-93.3% of water cons.
Solid line recorded pumpage of sewage at Deer Island Pumping Sta
Dotted line estimated quantity of sewage excluding storm water
Million Gallons per Day
60
80
100
Sun
Sun
Sun
Sun
Sun
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
P-8
September 1906
Fig 3
Rec. 168 P 37

38 In all cases, the quantity of sewage doubtless includes some ground water, and the usual quantity of manufacturing wastes, the water for which is derived from sources other than the water supply.

As has been pointed out, ground water stands or flows at a higher elevation in the spring than during other seasons of the year. A study of the records of the North Metropolitan sewer for the month of April in several years throws some light upon the average quantity of leakage which may be expected during that month. In a manner similar to that already described in determining the ratio of dry weather flow of sewage to the water consumption, Fig. 10 has been plotted, showing by the solid lines, the sewage pumped for each day of the month. The dotted lines indicate the probable quantity of sewage eliminating the storm water. Taking April, 1906, as an illustration, it appears that the quantity of sewage averaged 70.2 million gallons per day. Ninety per cent of the water consumption, which has been found to be equivalent to the dry weather flow in the intercepter, was 40.2 million gallons daily, leaving a surplus at this time of 30 million gallons per day. As the quantity of manufacturing wastes for the district were included in figures upon which the estimate of the dry weather flow of sewage (90% of water consumption) was based, it is evident that this difference of 30,000,000 gallons per day represents the quantity of ground water in excess of that present in very dry weather, which found its way by

39 infiltration into the sewers. As there were 652.5 miles of sewers tributary to the system at that time, the excess leakage averaged 46,000 gallons per day per mile of sewers. The tributary area was 17,561 acres, making the average daily leakage, (in excess of that during very dry weather), say 1,707 gallons, while the daily leakage per capita was 61.6 gallons.

(Here follows diagram, Fig. 10, marked page 40, Complainants' Exhibit 158.)

The month of April in four different years has been studied in a similar manner, and the results are given in Table 24.

TABLE 24.

Estimated Average Daily Quantity of Ground Water Leaking into North Metropolitan Sewer System in April, Boston, Mass.*

	Leakage, gals. per mile of sewers.	Leakage, gals. per acre.	Leakage, gals. per cap.	Rainfall.	
				Inches.	Previous month.
(1)	(2)	(3)	(4)	(5)	(6)
April, 1904.....	47,900	1,727	62.7	9.28	2.84
April, 1905.....	33,700	1,240	44.5	2.63	2.86
April, 1906.....	46,000	1,707	61.6	2.32	7.32
April, 1909.....	27,600	1,056	38.3	3.92	3.90

From this table, it appears that the average quantity of leakage in April in excess of that in August, varied from 27,600 to 47,900 gallons per day per mile of sewer, and from 1,056 to 1,727 gallons per day per acre. The largest quantity of leakage was in April, 1904, when the rainfall for the month was 9.28 inches. The next largest quantity was in April, 1906, when the rainfall was but 2.32 inches; but during the previous month there was a rainfall of 7.32 inches, which undoubtedly had much to do with the high ground water of the month in question.

41 To these quantities should be added the leakage during the dry weather, when the sewage was found to be equivalent to 90% of the water consumption. It is extremely doubtful if this leakage ever falls below 10,000 gallons per day per mile of sewers. Adding 13,000 gallons per mile to the quantities given in Table 24, the total average leakage per acre and per capita per day would be as shown in Table 25.

* In excess of ground water leakage during month of August.

TABLE 25.

Estimated Average Daily Quantity of Ground Water Leaking into North Metropolitan Sewer System.

(Assuming that leakage during driest months = 10,000 gals. per day per mile of sewer.)

Month.	Leakage in gallons per day per		
	Mile of sewer.	Acre.	Capita.
(1)	(2)	(3)	(4)
April, 1904	57,900	2,089	76
" 1905	43,700	1,607	58
" 1906	56,000	2,078	75
" 1909	37,600	1,469	52

In considering these figures, it must be remembered that they are average figures for the entire month, and it can readily be seen that the maximum quantity of leakage would be far in excess of this quantity. On the other hand, the tributary area is very completely sewered—23.8 miles of sewers per square mile—and many of the trunk sewers lie in wet ground and were built at a time when less care was taken to exclude ground water than at present. In calculating this area, only the districts directly tributary to sewers now built are included, and as they are located within a much larger tributary but unsewered area, the unit leakage is undoubtedly higher than will be the case when the entire district is completely sewered.

42 Miles of Sewers Per Unit of Area.

Table 26 compiled from data furnished in the special report of the United States Census Bureau upon "Statistics of Cities for 1905," shows the number of miles of sewers existing in various cities of the United States at that time. It appears that Boston had the greatest mileage,—18.4 miles of sewers per square mile of area,—while Milwaukee was second with 17.2 miles. These figures undoubtedly include areas somewhat suburban in nature which were not completely sewered. It would seem therefore, that an estimate of about 17 miles of sewers per square mile would be reasonable for Milwaukee in the future.

Estimate of Ground Water Reaching Sewers in Milwaukee.

There are certain portions of Milwaukee which yield considerable ground water, and others in which the soil is of blue clay and hardpan where scarcely any water is met in excavations for sewers. Comparatively small areas are low and lie adjacent to the rivers, but as a rule the land rises rapidly from the rivers. There are no indications of unusual leakage here, and provision for leakage amounting at times to 70,000 gallons per mile of sewer would appear to be ample.

We have assumed an allowance of 1,960 gallons per day per acre for maximum leakage. If the extent of the sewers is taken as 17 miles per square mile, this allowance for ground water corresponds to a leakage of 73,700 gallons per mile of sewers. So great a
43 quantity of leakage will be of comparatively short duration, but the studies of the records of the North Metropolitan System, and experience in other places indicates that at least as much as one-half this quantity or 980 gallons per day, per acre may be expected for a month or more at a time. These allowances may be summarized as follows:

Maximum Rate of Leakage.

1960 gals. per day per acre, or approximately 0.003 cu. ft. per second per acre.

Rate of Leakage Probable for One or Two Months at a Time.

980 gals. per acre per day, or approximately 0.0015 cu. ft. per second per acre.

Quantity of Leakage at Maximum Rate, 1910.

(1960 x 14,374) = 76 gals. per day per capita.

373,857

Quantity of Leakage Probable for One or Two Months at a Time.

38 gallons per capita.

44

TABLE 26.

Miles of Sewers Per Square Mile of Area in Various Cities—1905.*

Name.	Population, 1905.	Area in sq. miles (approximate).	No. of miles of sewers.	Miles of sewers per sq. mile.
Boston, Mass.	595,380	38	700.6	18.4
Milwaukee, Wis.	312,948	22	379.8	17.2
Allegheny, Pa.	142,848	7	111.5	16.4
Detroit, Mich.	325,563	36	561.7	15.6
Memphis, Tenn.	121,235	15	221.0	14.7
Newark, N. J.	283,289	16	232.4	14.5
Rochester, N. Y.	182,022	19	241.3	12.7
Pittsburgh, Pa.	364,161	29	365.7	12.6
Buffalo, N. Y.	376,914	40	489.0	12.2
Jersey City, N. J.	232,699	13	115.5	11.9
Providence, R. I.	198,635	18	213.3	11.8
Syracuse, N. Y.	117,129	16	118.2	11.4
Kansas City, Mo.	179,272	26	282.0	10.8
Cleveland, Ohio	437,114	39	412.7	10.6
Columbus, O.	142,105	16	168.2	10.5
St. Louis, Mo.	636,973	61	609.2	9.9
Chicago, Ill.	1,990,750	183	1633.0	9.2
Philadelphia, Pa.	1,417,062	128	1041.2	8.1
Washington, D. C.	302,883	60	484.4	8.1
Toledo, O.	155,287	25	191.6	7.6
San Francisco, Cal.	.....	46	332.8	7.2
Omaha, Neb.	120,565	24	158.8	6.6
Cincinnati, O.	343,337	42	263.2	6.2
Louisville, Ky.	222,660	20	122.1	6.1
New Haven, Conn.	119,027	18	105.4	5.8
Indianapolis, Ind.	212,198	30	162.1	5.4
New York, N. Y.	4,000,403	327	1752.7	5.4
Denver, Colo.	150,317	58	307.8	5.3
Scranton, Pa.	116,111	19	95.0	5.0
Worcester, Mass.	128,135	37	176.8	4.8
Los Angeles, Cal.	.....	43	203.9	4.7
Minneapolis, Minn.	261,974	49	200.4	4.1
St. Paul, Minn.	197,023	52	210.2	4.0
New Orleans, La.	309,639	200	350.0	1.7
Baltimore, Md.	546,217	31	46.6	1.5

*From United States Census Bureau special Report of "Statistics of Cities, 1905."

45 Discussion of Results of Measurements of the Flow of Sewage from District No. 47, Milwaukee.

This district, comprising 358 acres, is residential in character and no industrial or mercantile wastes are known to be discharged into the sewer. It is completely sewered and practically built up, the density of population being 30.7 persons per acre, corresponding to a total population of 11,000.

The gaugings, covering a period of four days, were made in the 72 inch sewer in 15th Street, near the northerly line of Grand Avenue. The district tributary to this sewer lies between the northerly line of Grand Avenue and the southerly line of Walnut Street, and, in a general way, between 14th and 23rd Streets.

The results of these sewer gaugings have been summarized as follows.

TABLE 28.

Sewer Gaugings.

	Total quantity.	
Monday (8 A. M. Oct. 24 to 8 A. M. October 25)	950,000 gals.	
Tuesday (8 A. M. Oct. 25 to 8 A. M. October 26)	911,000 "	
Wednesday (8 A. M. Oct. 26 to 8 A. M. October 27)	884,000 "	
Thursday (8 A. M. Oct. 27 to 8 A. M. Oct. 28)	931,000 "	per day
Average	919,000 "	" "

Using these quantities as a basis of calculation it appears that the average flow of sewage per capita was as follows:

46 TABLE 29.

Sewage Flow Per Capita Per Day.

(30.7 persons per acre.)

Monday	86.4 gals.
Tuesday	82.8 "
Wednesday	80.4 "
Thursday	84.6 "
Average	83.5 "

The average quantity of sewage found to be flowing in this sewer was 83.5 gallons per capita per day. This consists of ground water and that portion of the water supply discharged into the sewers.

It has some times been suggested that an indication of the quantity of ground water flowing in sewers can be obtained by assuming that the minimum rate of flow during the night is equivalent to the ground water infiltration. Obviously the quantity of ground water finding its way into the sewers is the same at night as during the day, and it is also true in many cases that the quantity of sewage actually contributed to the sewers during certain hours of the night is extremely small, if not nil. As this is a residential district, it is probable that no serious error will result from the assumption that in this case the minimum rate of flow during the night represents the quantity of ground water leaking into the sewer system. The minimum rate of flow on each of the days when gaugings were made, reduced to gallons per capita, was found to be as follows:

TABLE 30.

Minimum Rate of Flow.

Tuesday (12:30 A. M.)	31.1	gals. per Cap. per day.
Tuesday (11:00 P. M.)	40.5	" " " " "
Thursday (1:00 A. M.)	38.2	" " " " "
Friday (1:00 A. M.)	39.1	" " " " "
Average	37.2	

The rate of flow was smallest at 12:30 A. M. Tuesday when the quantity of water flowing in the sewer was equivalent to 956 gallons per acre per day, corresponding to 31 gallons per capita per day. If it is assumed that this quantity represents the ground water, the remainder of the flow would represent the water supply reaching the sewer, amounting to 52.5 gallons per capita per day.

The fluctuation in the maximum rate of flow was very marked, being from 133 to 207 gallons per capita per day. The maximum rate of flow on each of the days when gaugings were made, was found to be as follows:

TABLE 31.

Maximum Rate of Flow.

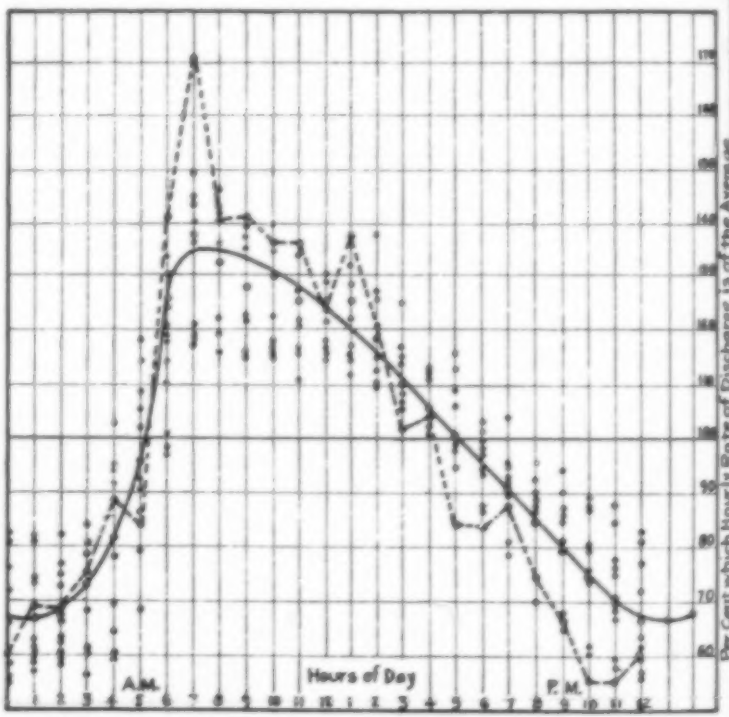
Monday (10:30 A. M.)	207	gals. per cap. per day.
Tuesday (10:30 A. M.)	133	" " " " "
Wednesday (8:00 A. M.)	149	" " " " "
Thursday (8:00 A. M.)	168	" " " " "
Average	164	gals. per cap. per day.

The ratio of the average maximum rate of flow to the average daily rate of flow $\frac{(164)}{(83.5)}$ is 1.96; that is, the average maximum rate

of flow was found to be nearly double the average daily flow.
48 This average maximum rate, however, is obtained by averaging the maximum rates of flow found on all of the four days when measurements were taken. These maximum rates, however, did not occur at the same hour of the day in each case, so that somewhat different results would be obtained by averaging the rates of flow for the same hour and selecting the maximum from this set of averages. The broken line, Fig. 11, shows the average rate of flow for each hour from District 47, for the four days covered by these gaugings.

This district is comparatively small in area, and the sewers are short and have rather steep grades. The longest sewer is about 1½ miles in length, and most of them are considerably shorter. The district is approximately rectangular in shape, about 5,000 feet long and 3,000 feet wide, on the average. On account of the size, shape, topography and residential character of the district, the measurements of the sewage show a fluctuation corresponding closely with that which would be expected. The fluctuation in the flow from the entire city at the outlet of the intercepting sewer will be very different from that of this or any other district, because of the equalizing effect due to difference in the length of trunk sewers in different districts, difference in the character of the districts, and storage in the intercepting sewers; so that the maximum rate of flow in and from the intercepting sewers will not be the same as that in the trunk Sewer of District No. 47.

(Here follows diagram, Fig. 11, marked page 49, Complainants' Exhibit 158.)



MILWAUKEE, WIS. Oct. 24-28, 1910
WORCHESTER, MASS. Nov. 13, 1909, Mar. 21-22, 1910
MARLBORO, MASS. Typical Average
TORONTO, CANADA 1901, 1902, 1903.

GLOVERSVILLE, N.Y. Oct. 20, 1906, Sept. 15, 1907
EAST ORANGE, N.J. Mar. 16-17, 1910
BIRMINGHAM, ENG. Aver. 2 years 1909

Full line is average of all gagings - points shown thus o
Dotted line is average of Milwaukee gagings, District #1 points shown thus •

SEWAGE DISPOSAL COMMISION
MILWAUKEE, WIS.

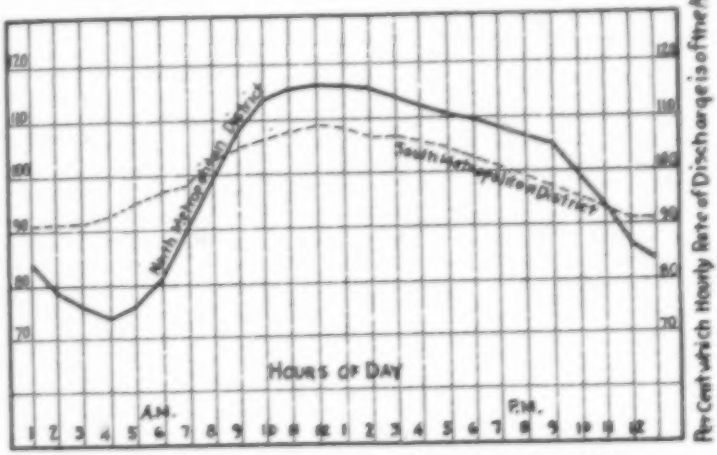
HOURLY VARIATION IN FLOW OF SEWAGE IN VARIOUS CITIES

December 20, 1910

John W. Alvord
George C. Whipple
Harrison P. Eddy
} Commission

E-10

Fig 11



NORTH METROPOLITAN DISTRICT Average of the weeks beginning November 2, 1908.
SOUTH " " " " " " " " 9 1909

NORTH METROPOLITAN SEWER Gaged near Chelsea and Everett line.
SOUTH " " " " Quincy

Hours apply to North Metropolitan District only
South Metropolitan curve moved forward 8 hours.

SEWAGE DISPOSAL COMMISSION
MILWAUKEE, WIS.

HOURLY VARIATION IN FLOW OF SEWAGE IN MASS. METROPOLITAN DISTRICTS

December 28, 1910.

John W. Alvord
George C. Whipple
Harrison P. Eddy
} Commission

E-11

Fig. 12.

The relative hourly rates of flow as obtained by measurements taken in various cities, are indicated by the dots upon Fig. 11. The results of averaging these measurements are indicated on the diagram by the small circles. The solid line is a curve drawn through many of the average points, and presents fairly well the average hourly fluctuation in the flow of sewage. In preparing this diagram, allowance has been made for the time consumed by the sewage in flowing to the gauging stations, and the gaugings have been so arranged that the early morning rise in flow shall come at substantially the same time in all of the cities. From this diagram it appears that the maximum rate of flow is, under average conditions, about 1.35 times the mean flow.

In Fig. 12 curves have been plotted showing the hourly fluctuation in the rate of flow in the North and South Metropolitan intercepting sewers, Boston. From these curves it appears that the maximum rate of flow in the North intercepter is only about 1.18 times, and in the South intercepter 1.09 times the average rate. In considering these curves it should be remembered that the intercepting sewers are very long and receive the sewage of many different cities and towns, which fact doubtless accounts for the smaller variation in flow than is shown by the curve in Fig. 11. It seems probable also that the fluctuation in the rate of flow from the City of Milwaukee would be somewhat greater than that of the North Metropolitan District.

(Here follows diagram, Fig. 12, marked page 51, Complainants' Exhibit 158.)

The average rate of flow through the day time, say from 9 A. M. to 5 P. M. in District 47, for the four days when the flow was gauged, was 1.33 times the average rate of flow for 24 hours.

52 Industrial Wastes.

Milwaukee is essentially a manufacturing city, being fortunate in the possession of many and varied industries. Several of these produce comparatively large quantities of waste liquors which are now discharged into the sewers or rivers. No effort has been made to obtain a complete census of the quantity of industrial wastes, although several of the manufacturies known to produce large quantities of waste liquors was visited, samples of the wastes collected for analysis and estimates made of the quantity of water used, as an index to the quantity of wastes which will be likely to be discharged into the sewers. The results of this investigation, so far as they pertain to the quantity of wastes are given in Table 32.

TABLE 32.

Quantities of Water Used by Several Manufacturies in Milwaukee.

Plant. (1)	From private water supply. (2)	City water. (3)
	(Gals. per day.)	
Plankington Packing Co.	400,000	.....
Layton Packing Co.	200,000	Boilers only
Bodden " "	45,000	55,000 gals.
Gunz " "	80,000	per day
Pabst Brewery	1,000,000 to 2,000,000	.....
Schlitz "	2,000,000	1,000,000
Blatz "	500,000	400,000
Pfister & Vogel's Tannery	800,000	400,000
Trostel & Sons	600,000	.....
American Hide & Leather Co.	350,000	.....
Milwaukee Coke & Gas Co.	475,000	.....
Total	7,450,000	gals. per day.
Johns-Manville Asbestos Works		500,000 (not now within city limits).

53 This quantity of water taken from private supplies is equivalent to about 20 gallons per capita per day. There are no doubt many other industrial plants provided with water from private sources, so that the total of such supplies will materially exceed this quantity; in fact, a consumption of 50 or 60 gallons per capita per day from private sources, is not unreasonable. The greater part of this water is likely in the future to be discharged into the sewers after it has been used, although this may not be true at the present time.

Additional light is thrown upon the quantity of industrial wastes likely to be received into the sewers by a series of gaugings of the flow in the trunk sewers in 1910.

Discussion of Measurements of Flow in Trunk Sewers.

During April and May, 1910, Mr. George L. Thon of Mr. Alvord's office, made gaugings of most of the sewer outlets. The results of these gaugings are given in Table 33.

The district numbers, gross areas, and sewered areas of the various sewer districts are given for reference in Table 34.

The only sewers in which the flow was not gauged were those in districts 3, 4, 40 and 42. The total of the quantities of sewage found to be flowing at the hours when gaugings were made was at the rate of 82,500,000 gallons per day. This quantity was produced on a total of 10,803 acres of sewered area, and is equivalent to 7,640 gallons per acre per day.

4303

Table 33.

Estimated Quantities of Industrial Wastes from Each District Based on Gaugings and Computations.

District No.	Popul. per acre of sewered area.	Est. of total water supply contributed plus ground water at time of gaugings, gals. per day.	Measured flow of sewage, gals. per day.	Diff. assumed to be max. rate mfg. wastes, gals. per day.	Total mfg. wastes $\frac{\text{No. 5} \times 1.24}{0.7}$, gals. per day.	Total industrial wastes. Gals. per day per acre of sewered area.	Total industrial wastes. Gals. per capita per day.
Sewers Flowing into Milwaukee River:							
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	16.6	465,300	97,000	.....	.....	.....	...
2	16.6	1,318,000	2,338,000	1,020,000	566,600	1,479	89
5	15.7	561,000	1,770,000	1,209,000	671,800	3,359	214
6	33.5	607,200	732,000	124,800	68,900	510	15
7	38.3	233,400	364,000	130,600	72,550	1,500	39
8	34.9	176,000	1,085,000	909,000	505,200	13,020	373
9	29.9	210,500	169,000	.....	.....	.....	...
10	29.9	236,300	870,000	633,700	352 000	6.170	206
11	29.9	182,000	980 000	797,400	442,600	9,900	331
12	28.6	111,200	486,000	374,800	208,400	7,550	264
13	28.0	484,200	2,195,200	1,710,000	950,000	7,780	278
14	27.1	79,950	538,000	458,050	254,400	12,350	456
15	27.1	87,750	603,000	515,250	286 100	12,660	467
16	27.1	88,950	227,000	138,050	76,700	3,355	124
17	27.1	132,700	91,000	.....	.....	.....	...
18	27.1	187,300	78 000	.....	.....	.....	...
23	22.2	75,650	55,000	.....	.....	.....	...
21	22.2	47,900	603,000	555,100	308,300	22,000	991
43	32.5	357,300	1,950,000	1,592,700	884,200	10,870	334
44	32.5	154,000	1,650,000	1,496,000	831,000	23,680	728
46	29.6	476,000	3,480,000	3,004,000	1,668,000	14,430	487
49	38.6	254,500	552,000	297,500	165,100	3,223	84
50	45.9	427,000	603,000	176,000	97,700	1,294	28
51	50.8	734,300	6,650,000	5,915,700	3,285,000	27,370	538
52	46.7	2,065,000	6,810,000	4,745,000	2,636,000	7,320	157
53	31.1	4,238,000	5,030,000	792,000	439,900	444	14
54	32.6	2,617,000	3,100,000	485,000	268,300	479	15

56	24.5	821,000	525,000	.....	.....	.....	...
57	45.8	546,500	3,050,000	2,503,500	1,392,000	14,390	314
Sewers Flowing into Menomonee River & Intercepting Sewer:							
20	22.2	266,000	168,500	.....	.....	.....	...
23	22.3	187,200	422,000	234,800	130,400	2,388	107
24	22.6	154,200	217,000	62,800	34,750	780	34.5
25	22.6	48,500	213,800	165,300	92,000	6,550	290
26	22.7	143,200	427,500	284,300	157,750	3,820	168
27	19.7	650,000	434,000	.....	.....	.....	...
28	22.1	825,000	434,000	.....	.....	.....	...
29	23.3	592,000	1,630,000	1,038,000	577,500	3,436	147
30	29.4	1,584,000	1,150,000	.....	.....	.....	...
45	29.2	404,000	1,430,000	1,026,000	570,000	5,765	197
47	30.6	1,832,000	923,000	.....	.....	.....	...
48	32.9	6,780,000	8,690,000	1,910,000	1,061,000	694	21
55	27.3	5,840,000	3,460,000	.....	.....	.....	...
Sewers Flowing into the Kinnickinnic River:							
22	22.2	257,200	1,447,500	1,190,300	661,500	8,795	396
31	27.0	833,500	852,250	18,750	10,420	48	2
32	22.2	185,200	71,100	.....	.....	.....	...
33	21.6	419,500	2,198,000	1,778,500	986,500	9,395	435
34	21.5	269,200	627,000	357,800	198,700	2,474	115
35	38.	920,200	763,000	.....	.....	.....	...
36	42.3	4,810,000	7,440,000	2,630,000	1,462,000	1,792	42
37	39.5	1,209,000	2,250,000	1,041,000	578,000	2,698	68
38	18.5	299,200	316,900	17,700	9,840	1,008	55
39	21.5	256,600	129,300	.....	.....	.....	...
41	15.4	341,000	132,500	.....	.....	.....	...

55 Applying this quantity to the total sewered area of the city (12,137.3 acres), the corresponding flow of sewage would be at the rate of 92,750,000 gallons per day, which represents the total quantity produced at this time in the day (say between 9 A. M. and 4 P. M.), by all districts, including those which were not gauged.

Assuming that 70 gallons per capita per day of the municipal water supply are delivered to the sewers in the form of sewage, as previously discussed, the present population of 373,857 people would contribute 26,170,000 gallons per day.

April and May are months during which the ground water is generally found to be high, and it would seem to be a conservative assumption that the average leakage during the period covered by these measurements amounted to 37,000 gallons per day per mile of sewers, or 980 gallons per acre per day. (The analysis of measurements of flow in District No. 47 showed 560 gallons per day per acre in October.) While the entire City is not sewered, there is little doubt that the ground water from a larger area than that actually sewered is received into the sewers, and for that reason it is fair to use, in these calculations, the actual area within the City limits (14,374 acres). On this basis the quantity of ground water finding its way into the sewers would be 14,090,000 gallons per day, which added to the water supply contributed, would amount to 40,260,000 gallons per day, as the amount of domestic sewage and ground water.

56 Assuming that the flow of ground water and water supply contributed during that portion of the day within which the guagings were made,—from 9 A. M. to 4 P. M.—was 135% of the average flow for the twenty-four hours, (based on measurements of flow in district No. 47), the flow during this period would be at the rate of 54,350,000 gallons per day. Deducting this quantity from the rate of flow calculated from the gaugings, 92,750,000, there is found to be a difference of 38,400,000 gallons per day, which represents the rate of flow of industrial wastes during these hours of the day.

By far the larger portion of industrial wastes are discharged during ten hours of the day. Assuming that ¾ of the total quantity represents this portion, and that the discharge is uniform during the ten hours, it appears that 16,000,000 gallons (10/24 × 38.40 m. g. d.) is equivalent to ¾ of the quantity produced per day, and that the total quantity would be 21,350,000 gals. per day, equivalent to 57.2 gallons per capita.

The result of these measurements and the calculations based upon them, to the effect that the quantity of manufacturing wastes discharged into the sewers amounts to about 21 million gallons per day, does not seem unreasonable. It should also be remembered that some of the industrial wastes are now discharged into the rivers. Such of these wastes as may tend to seriously pollute the rivers should be diverted from them into the sewers as soon as the intercepters are put into use.

57 The fact that a single industrial plant may discharge as great a quantity of wastes as 3,000,000 gallons per day, equivalent to nearly 10 gallons per capita for the entire population

of the city, is further evidence that an estimate of 60 gallons per capita per day of industrial waste from the entire city is not unreasonable.

Milwaukee is very favorably situated to provide a cheap supply of water for industrial purposes, as plants located near any of the rivers and canals can secure water from them. As soon as the sewage is intercepted this water will be of fairly good quality, and can be used without purification for many of the rougher purposes, and where a water of comparatively high degree of purity is necessary, as for dyeing delicate tints, the river water can be purified locally at comparatively small expense. It seems logical therefore, that Milwaukee should continue to be a favorable location for industries requiring large quantities of water, and that, in estimating the future quantity of sewage to be purified, provision should be made for as great a quantity of industrial wastes as appears to be produced at the present time, and it should further be assumed that, as at present, the industries will be supplied with water largely from wells and from the rivers.

In columns 7 and 8, Table 33, is recorded the quantity of industrial wastes per acre and per capita, respectively, calculated as being produced in the various districts. The calculations have been made for each district, by the method just described in calculating the total quantity of industrial wastes. It will be noticed that in a few of the districts, as for example Districts 1, 17, 18 and 19, the quantity of sewage measured was not in excess of the estimated quantity of water supply contributed and ground water flowing in the sewers at the time the measurements were taken. These districts are, we believe, without exception, residential in character, so that industrial wastes were not to be expected. The quantity of industrial wastes from the different districts varies from 2 to 991 gallons per capita per day. The districts in which this unit quantity is found to be particularly high are those which are known to contain numerous industrial or mercantile houses, and therefore, it is considered that the results of this calculation are reasonable and reliable. The maximum quantity of industrial wastes produced per acre of sewered area was 27,370 gallons per day for District 51. The quantities vary greatly.

58

Summary of Calculations and Estimates of Quantities of Sewage.

Summarizing the foregoing calculations and estimates, the quantity of sewage produced in 19-0 would be made up as follows:

TABLE 35.

Quantity of Sewage, 1910.

	Mil. gals. per day. (1)	Gals. per cap. per day. (2)	% of flow. (3)
Water supply contributed	26.17	70	42.4%
Ground water*	14.09	38	23.
Industrial wastes	21.35	57	34.6
Total	61.61	165	100.0

*When leakage is moderate.

59 This quantity, equivalent to 165 gallons per capita, may be expected for periods of one or two months in the spring, and for periods of several days, possibly a month at a time, occasionally during other seasons of the year. It is probably somewhat above the annual average quantity which will be delivered to the disposal works.

The water supply contributed in the form of sewage is estimated to be 42% of the total sewage flow, and the manufacturing wastes nearly 35%. The quantity of sewage estimated for 1910,—61,610,000 gallons per day,—is 1.58 times the daily average water consumption for the year. It should be remembered that this estimate includes a moderate amount of leakage, though not more than may be expected for one or two months at a time. This estimate is therefore probably somewhat greater than the average quantity of sewage actually discharged into the rivers. It is interesting to note, in this connection, that the quantity of sewage in the North Metropolitan District of Boston, for the years 1904 to 1909 inclusive, was 1.23 times the water consumption.

There will be comparatively short periods of time, say from one to two weeks' duration, during which the quantity of ground water reaching the sewers will be considerably in excess of that included in the foregoing estimate of 61.61 million gallons per day. Assuming that this excess quantity of ground water would be equal to that already included, (980 gallons per acre), the total sewage flow would become 75.7 million gallons per day, equivalent to 286 gallons per capita.

60 Neither of these estimates includes any storm water. The estimates of the quantity of ground water per acre and of manufacturing wastes per capita are uniform throughout the period of forty years considered in this report. The quantity of water supply contributed has been gradually increased as previously explained. The population and the area of the City are increased so that the total quantity of sewage per capita varies from time to time in accordance with the growth of the city and the increase in the quantity of water consumed. The unit and total quantities used in and resulting from these calculations are given in Tables 36 to 37 inclusive.

The basis of design of the works for the clarification or purification of the sewage should be the average quantity of sewage per day when leakage is moderate, which has been estimated at from 165 to 182

gallons per capita, equivalent to 100,000,000 gallons in 1930 and 155,000,000 in 1950, calculated upon the estimated population for those years. Due consideration should be given, however, to the fact that very much larger quantities of sewage will be received in time of storm, and that there will be a material fluctuation in the rate of flow from day to day, and from hour to hour during the day. The capacity of the intercepting sewers, the pumping station and the outfall, cannot be based upon the average quantity of sewage, but must be proportioned according to the maximum rate of flow to be provided for.

In tables 38 and 40 are given the estimated maximum rate of flow in gallons per capita, and in million gallons per day.

61 Column 2, Table 38, gives the estimated maximum rate at which the water supply will be contributed to the sewers. It is obvious that the quantity of ground water will not vary from hour to hour during the day. It has already been explained that the maximum rate of domestic sewage flow will be about 135% of the average rate.

From Table 37, it is seen that in 1910 the estimated sewerage water supply contributed is 70 gallons per capita, and the leakage 38 gallons per capita. The total of these two items would, therefore, be 108 gallons per capita, which represents the average quantity of domestic sewage. This would be increased to 135% at times of maximum discharge, the quantity then being about 146 gallons. Deducting the ground water, 38 gallons, we have the maximum rate at which the water supply is contributed,—108 gallons per capita per day.

It has been assumed that three-quarters of the industrial wastes will be discharged in ten hours, so that the maximum rate of discharge will be 103 gallons per capita, (column 3, Table 38). Adding the maximum rate of water supply contribution, the maximum rate of industrial wastes and the leakage when moderate, it appears that in the year 1910, the estimated maximum rate of total sewage flow will be 248 gallons, and in 1950, 271 gallons per capita per day. At times when the leakage into the sewers is excessive, the maximum rate of flow is estimated to be 285 gallons and 312 gallons per capita per day in 1910 and 1950 respectively.

62 From the foregoing discussion, it is evident that if the intercepting sewers are to have a capacity sufficient for a population of 850,000 people, as estimated for 1950, they must provide for a maximum rate of flow of 312 gallons per capita daily. It is realized that these estimates are based upon somewhat unsatisfactory data, and no provision whatever is made for storm water. In view of the advisability of continuing the flushing of the rivers, and the practical impossibility of preventing the bacterial infection of the waters of the bay, and possibly the water supply, it does not seem wise to provide for the pumping, clarification and disposal into the Lake at the new outlet, of a material proportion of the storm water. It has, therefore, been decided not to attempt to collect in the intercepting sewers, large quantities of storm water, but to provide liberally for the maximum rate of flow at times when the leakage into

the sewers is excessive. Accordingly, the capacity of the interceptors has been based on an estimated flow at such times of 350 gallons per capita, or 38 gallons in excess of the estimate for 1950, given in column 7, Table 38. The quantity of sewage for which provision is made, will therefore, be 297,500,000 gallons daily (350 gallons per capita from a population of 850,000 people).

While no provision is made for storm water after the city reaches a population of 850,000, it is obvious that from the time the interceptors are built until this population is reached, there will be a surplus capacity which will be available for storm water. In
63 times of moderate flow, as during the warmer months of the year, the amount of this surplus capacity will be that given in Column 3, Table 41.

64 TABLE 36.

Population, Area and Water Consumption Used in Estimating Quantity of Sewage.

Year.	Population of city.	Area of city, in acres.	Water consumption, gals. per cap. per day.
(1)	(2)	(3)	(4)
1910	373,857	14,374	105
1920	475,000	19,531	110
1930	585,000	24,681	115
1940	715,000	29,844	120
1950	850,000	35,000	125

TABLE 37.

Units Used in Estimating Average Quantity of Sewage, in Gallons per Capita per Day.

Year.	Ave. water supply contributed.	Ave. industrial wastes.	Leakage when moderate.	Total ave. quantity of sewage when leakage is moderate.	Leakage when excessive.	Total ave. quantity of sewage when leakage is excessive.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1910	70	57	38*	165	75**	202
1920	73	57	40	170	81	211
1930	75	57	41	173	83	215
1940	80	57	41	178	82	219
1950	85	57	40	182	81	223

* Based on 980 gals. per acre per day.
** Based on 1960 gals. per acre per day = 200% of average.

TABLE 38.

Units Used in Estimating Maximum Rate of Flow of Sewage, in Gallons per Capita per Day.

Year.	Max. rate water supply contributed.	Max. rate industrial wastes.	Leakage when moderate.	Total max. rate of sewage flow when leakage is moderate.	Leakage when excessive	Total max. rate of sewage flow when leakage is excessive.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1910.....	108	103	38*	248	75**	285
1920.....	112	103	40	255	81	296
1930.....	116	103	41	260	83	302
1940.....	122	103	41	266	82	307
1950.....	128	103	40	271	81	312

* Based on 980 gallons per acre per day.
** Based on 1960 gals. per acre per day = 200% of average.

6

TABLE 39.

Year.	Ave. water supply contributed.	Ave. industrial wastes.	Leakage when moderate.	Total ave. quantity sewage when leakage is moderate.	Leakage when excessive.	Total average quantity of sewage when leakage is excessive.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1910..	26.17	21.35	14.09	61.61	28.18	75.70
1920..	34.41	27.20	19.12	80.73	38.24	99.85
1930..	43.80	33.40	24.20	101.40	48.40	125.60
1940..	57.20	40.80	29.22	127.22	58.44	156.44
1950..	72.25	48.80	34.30	155.15	68.60	189.45

TABLE 40.

Estimated Maximum Rate of Flow of Sewage, in Million Gallons per Day.

Year.	Max. rate water supply contributed.	Max. rate industrial wastes.	Leakage when moderate.	Total max. rate of flow of sewage when leakage is moderate.	Leakage when excessive.	Total max. rate of sewage flow when leakage is excessive.
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1910..	40.16	38.45	14.09	92.70	28.18	106.80
1920..	53.23	48.90	19.12	121.25	38.24	140.40
1930..	67.65	60.20	24.20	152.05	48.40	176.20
1940..	87.48	73.60	29.22	190.30	58.44	219.50
1950..	108.90	87.50	34.30	230.70	68.60	265.00

TABLE 41.

Surplus Capacity of Interceptors Available for Carrying Storm Water.

(Capacity of Interceptors 297.5 Million Gallons per day.)

Year.	Avg. rate of sewage flow when leakage is moderate (m. g. d.).	Surplus capacity of interceptor (m. g. d.).	Dilution of sewage at time overflow takes place.
(1)	(2)	(3)	(4)
1910	61.61	235.89	1 :3.83
1920	80.73	216.77	1 :2.68
1930	101.40	196.1	1 :1.93
1940	127.22	170.28	1 :1.34
1950	155.15	142.35	1 :0.92

It is therefore apparent that, for many years, comparatively large quantities of storm water will be collected by the intercepting sewers, and can be passed through the clarification works and discharged through the outfall sewer.

From table 41, it appears that the quantity of storm water which can be carried, were the sewers completed in 1910 would be 3.83 times the average flow of sewage when leakage is moderate; whereas in 1950, the quantity of storm water at such time would be nearly equal to the quantity of sewage. The dilution of sewage with storm water at the time of overflow would be increased or decreased as the quantity of sewage flowing at the time was less or greater than the average quantity.

The foregoing estimates of the quantity of sewage which will be produced have been made as the basis of design of sewers and disposal works. For calculations of operating conditions it may be desirable to use the annual average quantity of sewage which will probably be about 130 gallons per capita.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOW COMPLAINANTS' EXHIBITS RELATING TO DISSOLVED OXYGEN.

Shown in Nos. 159, 160, 161, 162, 163, 164, 165, 166, 167, 168, and 169.

JAMES D. MAHER,
Commissioner.

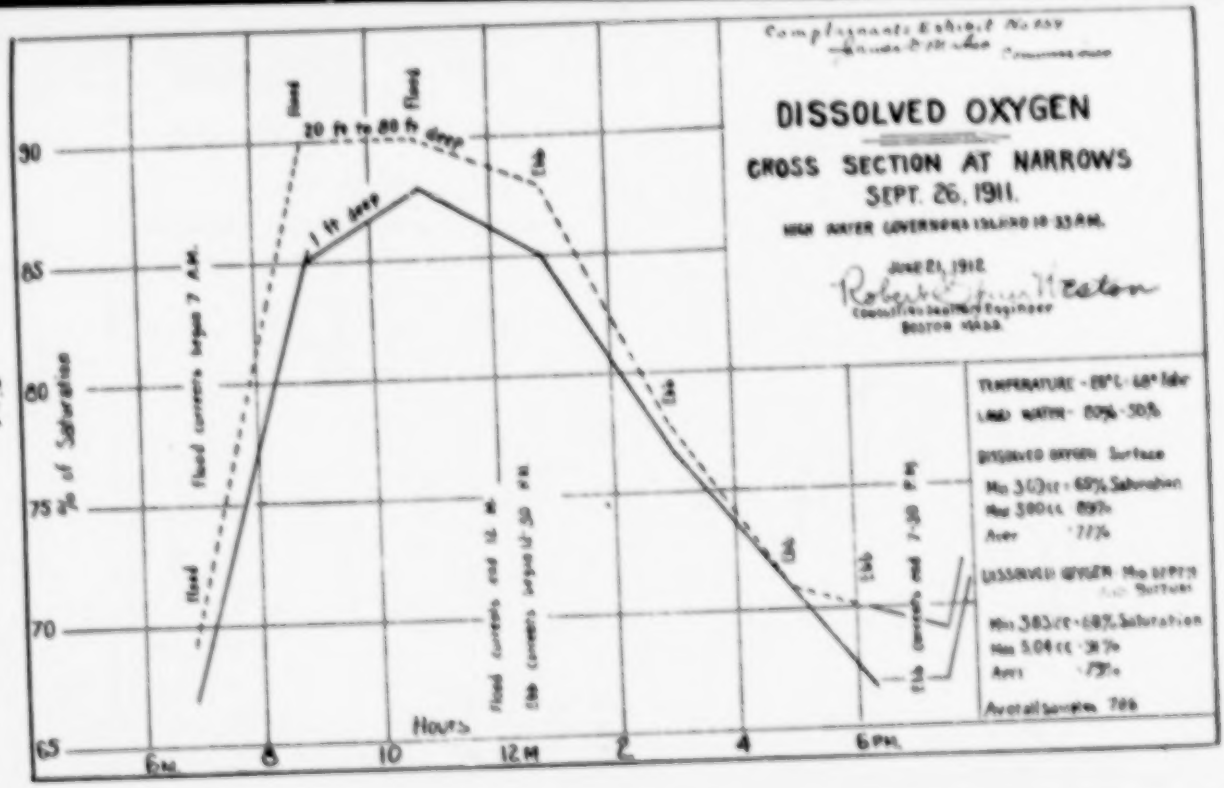

DISSOLVED OXYGEN
CROSS SECTION AT NARROWS
SEPT. 26, 1911.
HIGH WATER GOVERNORS ISLAND 10.33 A.M.
JUNE 21, 1912.
Consulting Sanitary Engineer
BOSTON MASS.
20 ft to 80 ft deep
1 ft deep
Flood
Flood
Ebb
Ebb
Ebb
Ebb
Ebb
Flood currents began 7 A.M.
Flood currents end 12 M.
Ebb currents began 1.30 P.M.
Ebb currents end 7.30 P.M.
% of Saturation
90
85
80
75
70
65
Hours
6 PM
8
10
12 M
2
4
6 PM
TEMPERATURE - 69°C - 68° Idle
LAND WATER - 80% - 50%
DISSOLVED OXYGEN Surface
Min 3.0 cc - 69% Saturation
Max 5.00 cc 89%
Aver 77%
DISSOLVED OXYGEN Min 0.7 P.P.M.
Min 3.83 cc - 68% Saturation
Max 5.04 cc - 38%
Aver 73%
Average all samples 70%

Fig 1

Complainants Exhibit No 160
James D Maher Commissioner

DISSOLVED OXYGEN

NEAR ROBBINS REEF LIGHT

OCT 16, 1911

LOW WATER GOVERNORS ISLAND 9.06 A.M.

AVERAGE OF STATIONS WITHIN ½ MILE OF LIGHT

JUNE 21, 1912

Robert Spurr Weston
Consulting Sanitary Engineer
Boston Mass

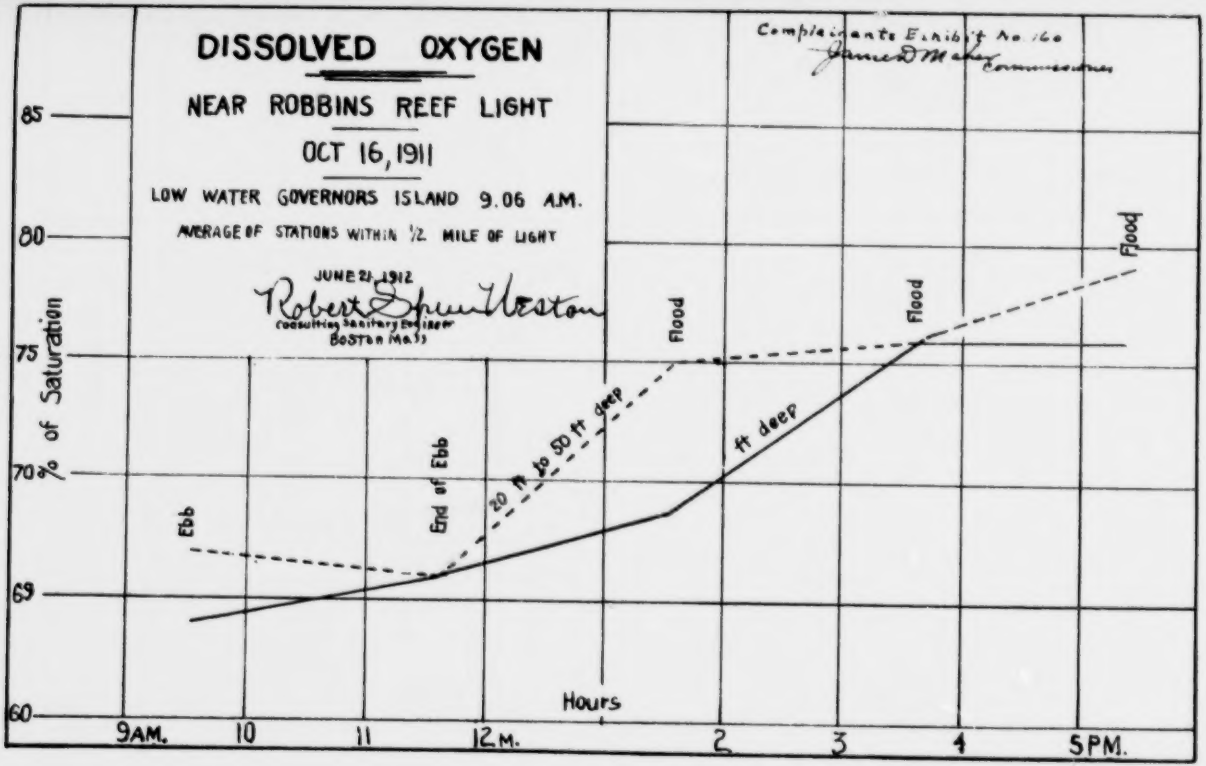


Fig 2

Complainant's Exhibit No 161
James J Maher
Commissioner

DISSOLVED OXYGEN

CROSS SECTION OF EAST RIVER

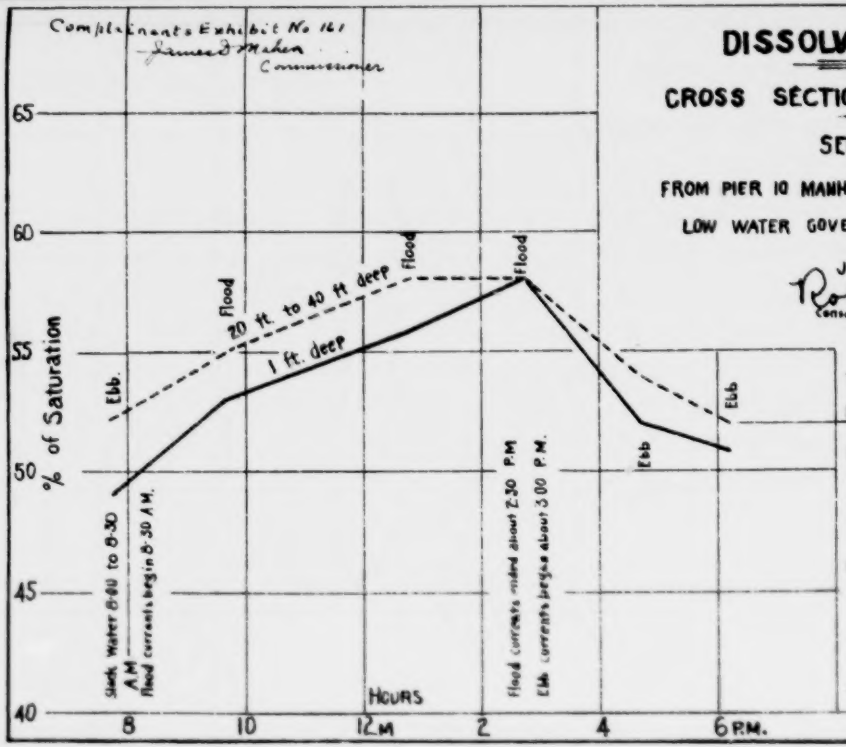
SEPT. 29, 1911.

FROM PIER 10 MANHATTAN TO PIER 10 BROOKLYN

LOW WATER GOVERNORS ISLAND 6-57 A.M.

JUNE 24, 1912

Robert Spurr Weston
Consulting Sanitary Engineer
BOSTON MASS.



TEMPERATURE - 20°C = 68° Fahr

LAND WATER - 28% - 34%

DISSOLVED OXYGEN SURFACE

Min 2.73 cc = 48% Saturation
Max. 3.36 cc = 60%
Aver. = 53%

DISSOLVED OXYGEN - MID DEPTH AND BOTTOM

Min 2.87 cc = 51% Saturation
Max 3.36 cc = 60% "
Aver = 55% "

Average of all Samples = 54% "

Fig 3

Complainant's Exhibit No 162.
James B. Maher
Commissioner.

DISSOLVED OXYGEN

CROSS SECTION OF EAST RIVER

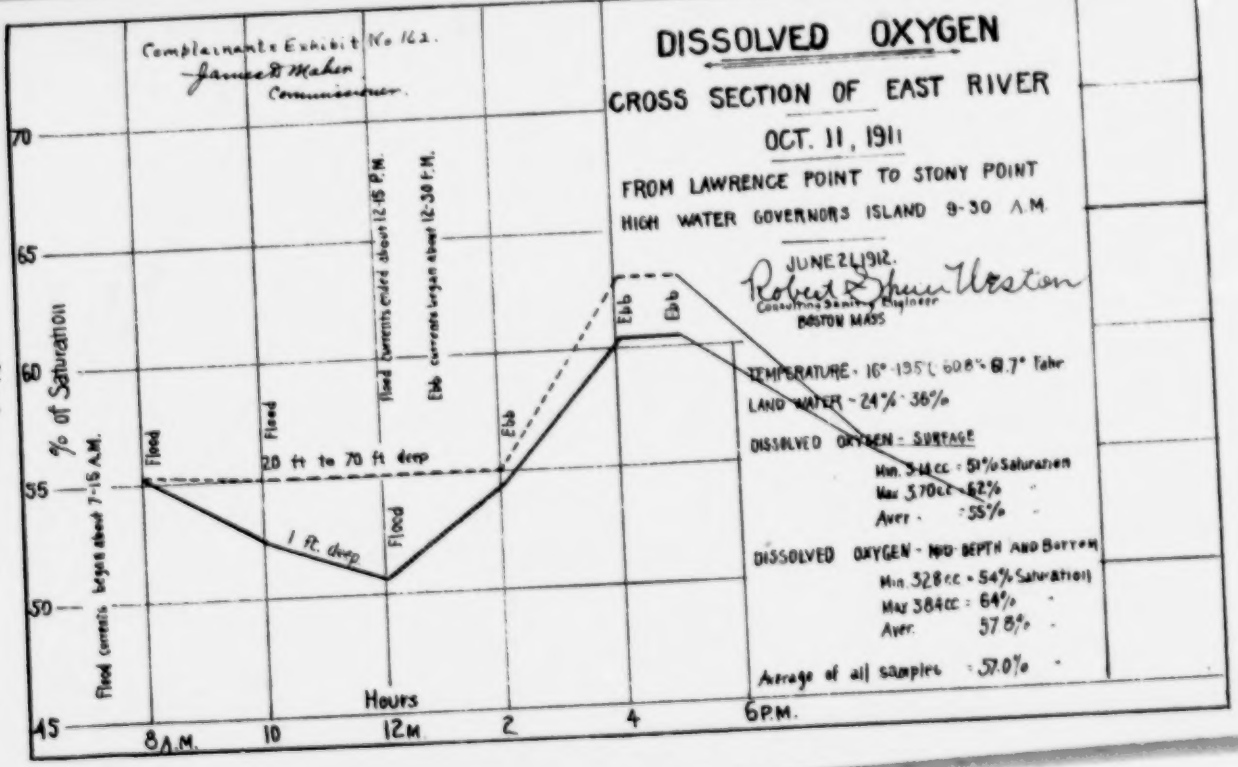
OCT. 11, 1911

FROM LAWRENCE POINT TO STONY POINT

HIGH WATER GOVERNORS ISLAND 9-30 A.M.

JUNE 24 1912.

Robert Spurr Weston
Consulting Sanitary Engineer
BOSTON MASS



TEMPERATURE - 16°-135°C 60.8°-61.7° Fahr

LAND WATER - 24°/. 36°/.

DISSOLVED OXYGEN - SURFACE

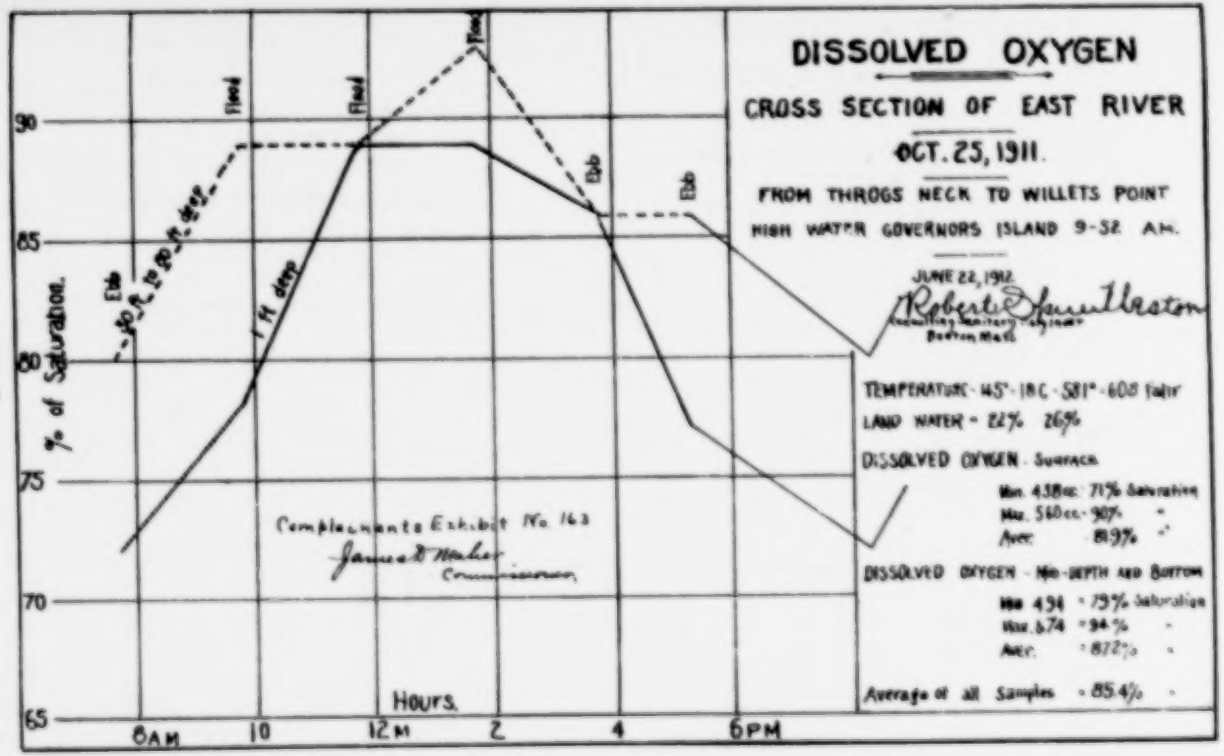
Min. 3.44 cc = 51% Saturation
Max 3.70 cc = 62% "
Aver. = 55% "

DISSOLVED OXYGEN - MID DEPTH AND BOTTOM

Min. 3.28 cc = 54% Saturation
Max 3.84 cc = 64% "
Aver. 57.8% "

Average of all samples = 57.0% "

Fig 4.


DISSOLVED OXYGEN
CROSS SECTION OF EAST RIVER
OCT. 25, 1911.
FROM THROGS NECK TO WILLETS POINT
HIGH WATER GOVERNORS ISLAND 9-52 A.M.
JUNE 22, 1912.
Robert Spurr Weston
Consulting Sanitary Engineer
Boston, Mass.
TEMPERATURE - 45° - 18 C - 581° - 608 Fahr
LAND WATER - 22% 26%
DISSOLVED OXYGEN - Surface
Min. 4.38cc - 71% Saturation
Max. 5.60cc - 90% "
Aver. 89.9% "
DISSOLVED OXYGEN - Mid-DEPTH AND BOTTOM
Min 4.94 - 75% Saturation
Max. 6.74 - 94.5% "
Aver. - 87.2% "
Average of all Samples - 85.4% "
Fig 5
% of Saturation.
90
85
80
75
70
65
Ebb
Flood
1 Ft deep
Hours.
8AM
10
12M
2
4
6PM
Complainants Exhibit No. 163
James B. Maher
Commissioner

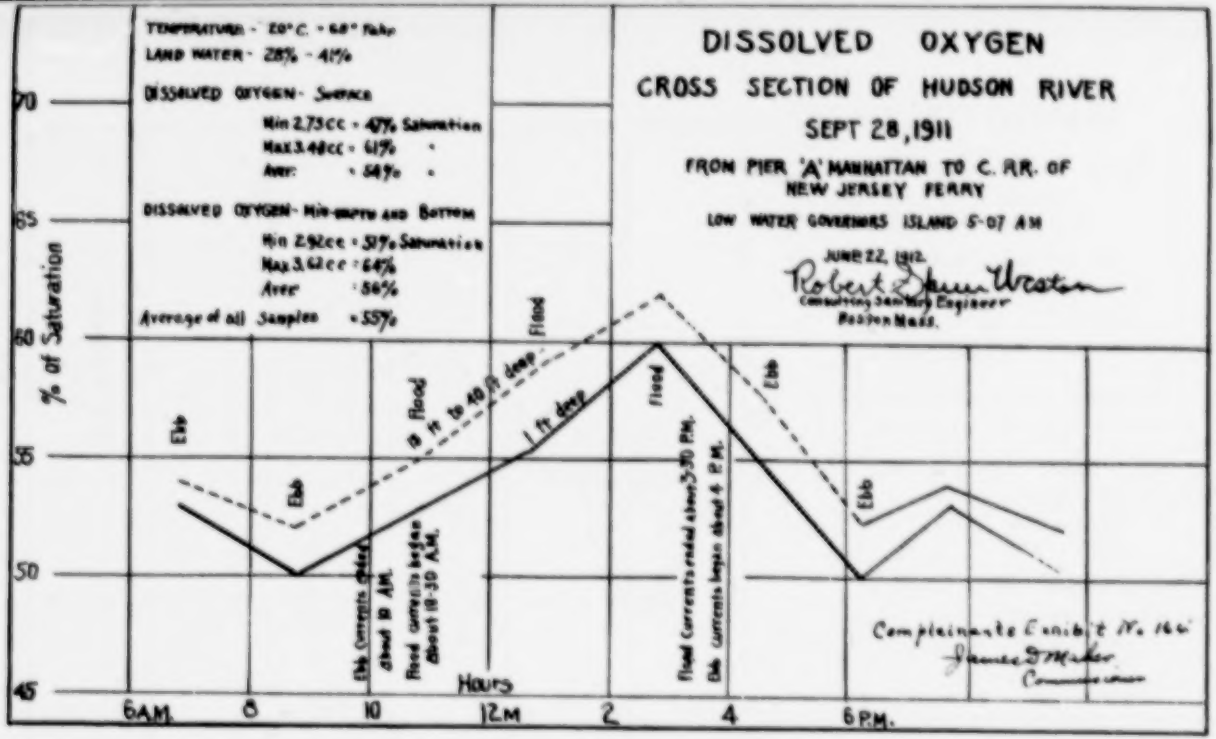

TEMPERATURE - 20° C. = 68° Fahr
LAND WATER - 28% - 41%
DISSOLVED OXYGEN - Surface
Min 2.73 cc = 47% Saturation
Max 3.48 cc = 61% "
Aver: = 54% "
DISSOLVED OXYGEN - Mid-depth and Bottom
Min 2.92 cc = 51% Saturation
Max 3.62 cc = 64%
Aver = 56%
Average of all Samples = 55%
DISSOLVED OXYGEN
CROSS SECTION OF HUDSON RIVER
SEPT 28, 1911
FROM PIER 'A' MANHATTAN TO C. RR. OF NEW JERSEY FERRY
LOW WATER GOVERNORS ISLAND 5-07 AM
JUNE 22, 1912.
Robert Spurr Weston
Consulting Sanitary Engineer
Boston Mass.
% of Saturation
70
65
60
55
50
45
Ebb
Ebb
Ebb Currents ceased about 10 A.M.
Flood currents began about 10-30 A.M.
0 ft to 40 ft deep
1 ft deep
Flood
Flood
Flood currents ended about 3-30 P.M.
Ebb currents began about 4 P.M.
Ebb
Ebb
Hours
6 A.M.
8
10
12 M
2
4
6 P.M.
Complainants Exhibit No. 166
James D. Miller
Commissioner

Fig. 6

Fig 7

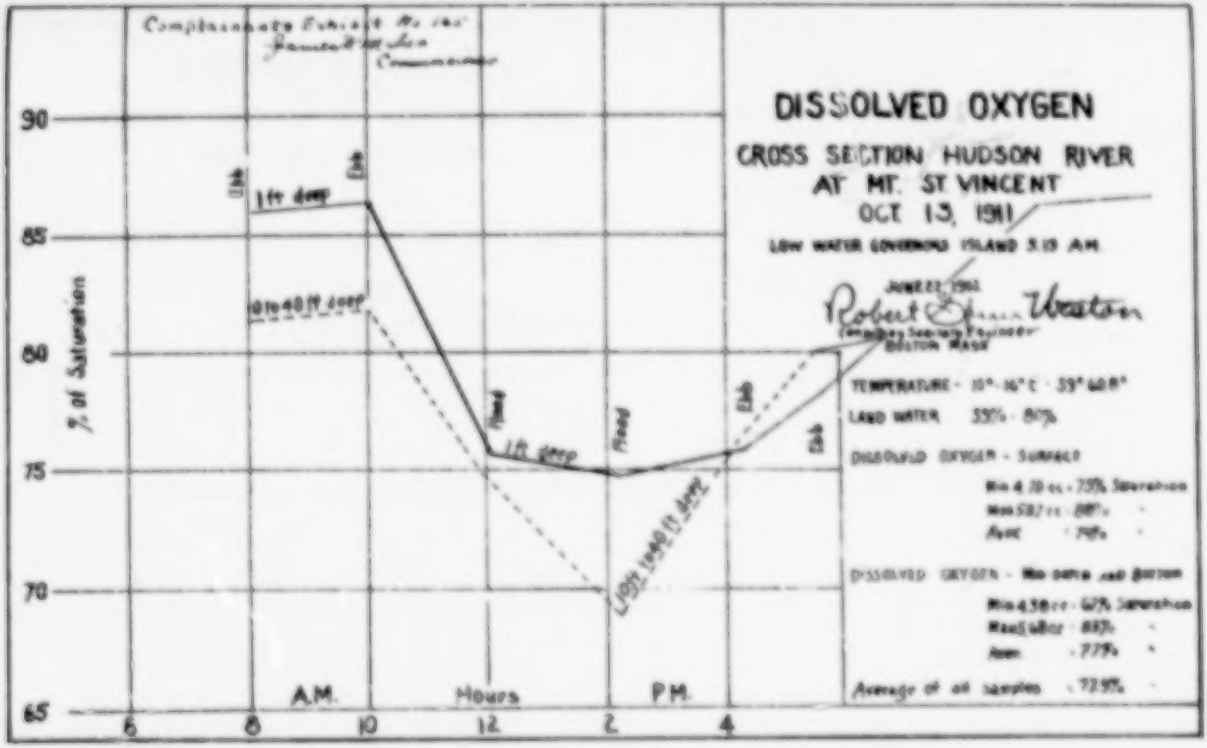

DISSOLVED OXYGEN
CROSS SECTION HUDSON RIVER
AT MT. ST VINCENT
OCT 13, 1911
LOW WATER GOVERNORS ISLAND 3.13 A.M.
Robert E. Thurston
TEMPERATURE - 11°-16°C - 39°-60.8°
LAND WATER 55% - 80%
DISSOLVED OXYGEN - SURFACE
Min 4.39 cc - 75% Saturation
Max 5.82 cc - 88% "
Aver - 79% "
DISSOLVED OXYGEN - Mid depth and Bottom
Min 4.58 cc - 67% Saturation
Max 5.80 cc - 88% "
Aver - 77% "
Average of all samples - 72.9% "
% of Saturation
90
85
80
75
70
65
1ft deep
10 to 40 ft deep
1ft deep
Light loads 12 deep
Flood
Flood
Ebb
Ebb
A.M.
Hours
P.M.
6
8
10
12
2
4

Fig 8

DISSOLVED OXYGEN

CROSS SECTION OF KILL VAN KULL NEAR NEW BRIGHTON

OCT. 4, 1911.

HIGH WATER GOVERNORS ISLAND 5.02 A.M.

June 24, 1912.

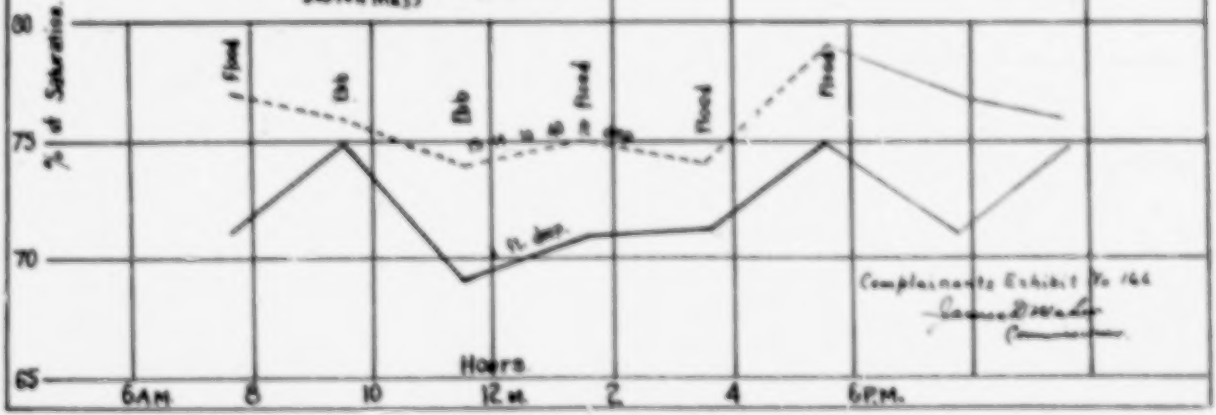
Robert Shaw Weston
consulting Sanitary Engineer
Boston Mass.

TEMPERATURE 17° (63°C - 62.6° - 63.3° Fahr.
LAND WATER - 26.5% - 34.5%

DISSOLVED OXYGEN SURFACE
Min 4.10 cc - 68% Saturation
Max 4.54 cc - 77% "
Aver. - 70% "

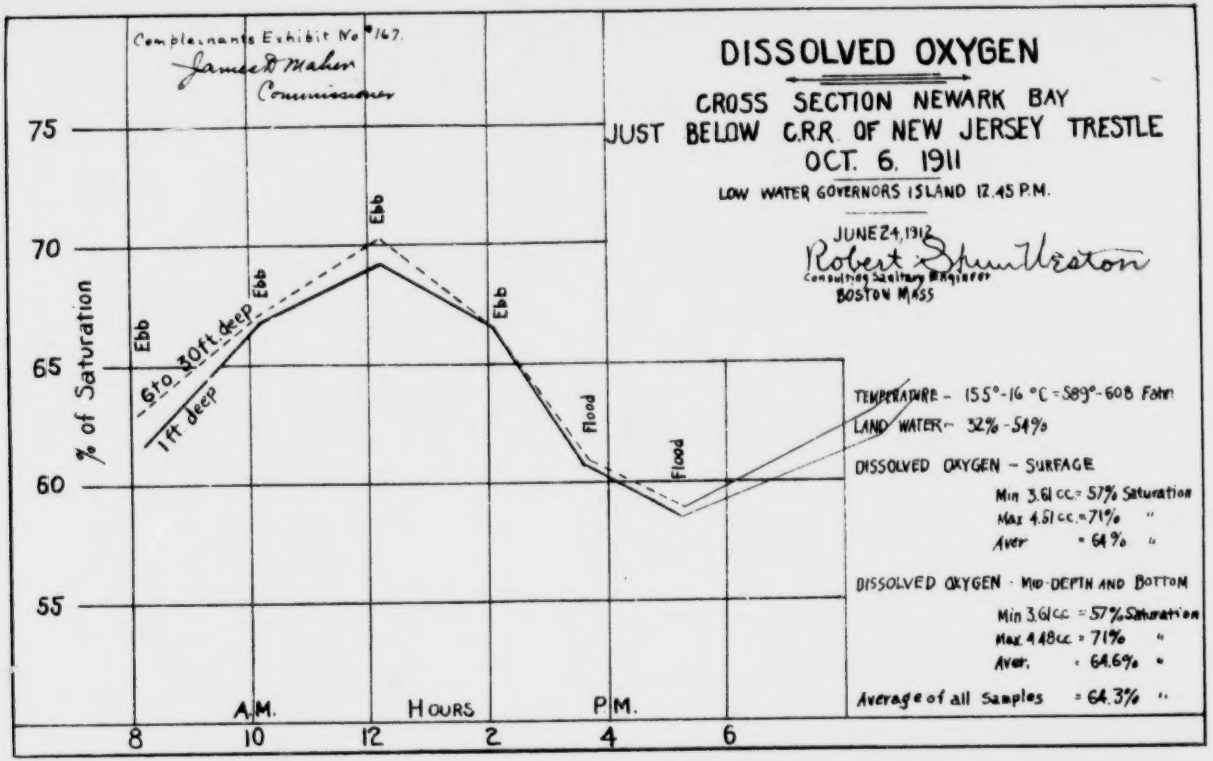
DISSOLVED OXYGEN Mid-depth and Bottom
Min 4.26 cc - 70% Saturation
Max 4.78 cc - 81% "
Aver. - 76% "

Average of all samples - 73% "



Complainants Exhibit No 164
Edward Wheeler
Commissioner

Fig 9.


Complainants Exhibit No 147.
James D Maher
Commissioner
DISSOLVED OXYGEN
CROSS SECTION NEWARK BAY
JUST BELOW C.R.R. OF NEW JERSEY TRESTLE
OCT. 6. 1911
LOW WATER GOVERNORS ISLAND 12.45 P.M.
JUNE 24, 1912
Robert Spurr Weston
Consulting Sanitary Engineer
BOSTON MASS
75
70
65
60
55
% of Saturation
Ebb
Ebb
Ebb
Ebb
Flood
Flood
6 to 30 ft deep
1 ft deep
A.M.
HOURS
P.M.
8
10
12
2
4
6
TEMPERATURE - 15.5°-16 °C = 589°-608 Fahr
LAND WATER - 32% - 54%
DISSOLVED OXYGEN - SURFACE
Min 3.61 cc = 57% Saturation
Max 4.51 cc = 71% "
Aver = 64.9% "
DISSOLVED OXYGEN - MID-DEPTH AND BOTTOM
Min 3.61 cc = 57% Saturation
Max 4.48 cc = 71% "
Aver. = 64.6% "
Average of all Samples = 64.3% "

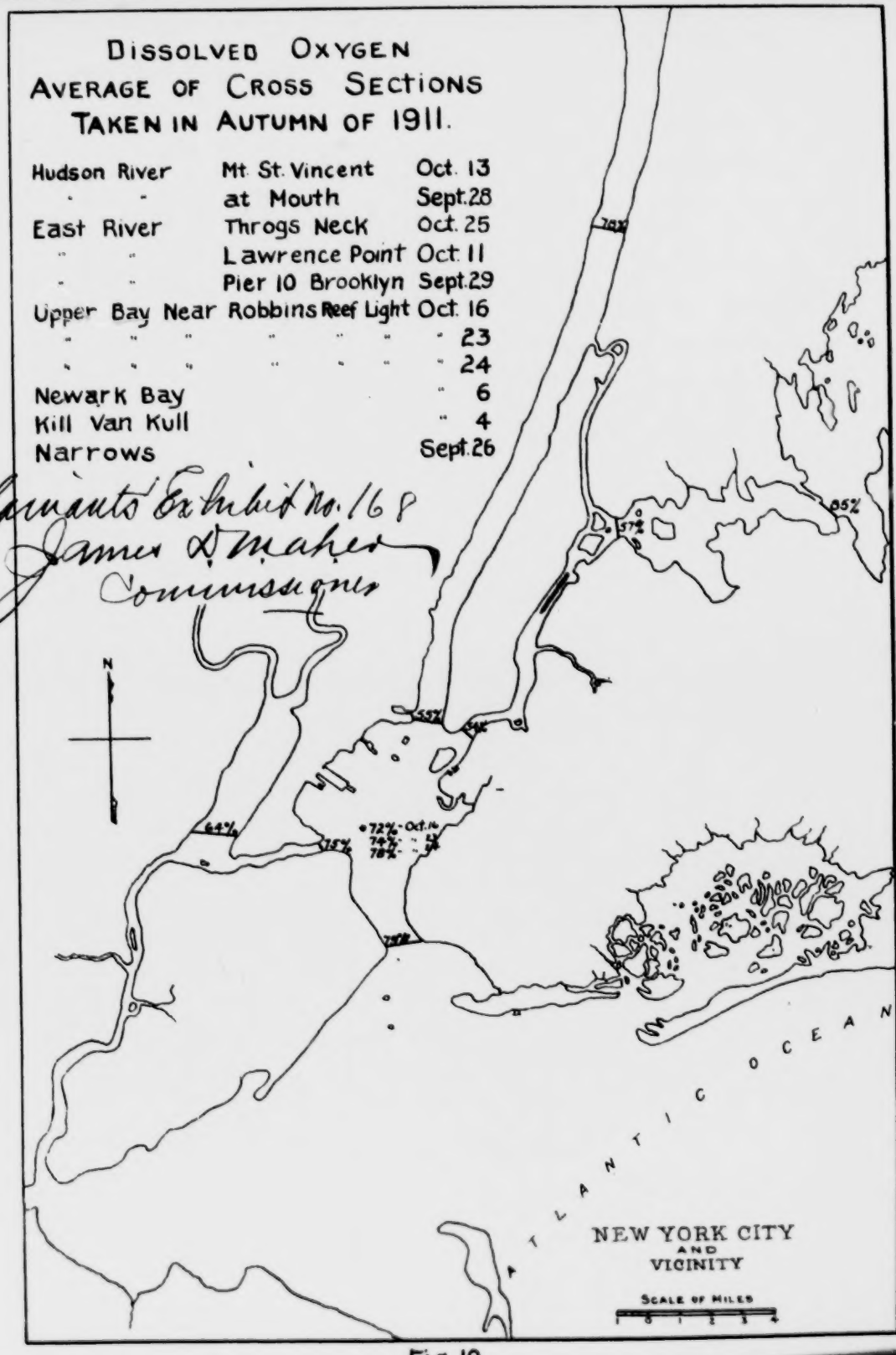

DISSOLVED OXYGEN
AVERAGE OF CROSS SECTIONS
TAKEN IN AUTUMN OF 1911.
Hudson River Mt. St. Vincent Oct. 13
" " at Mouth Sept. 28
East River Throgs Neck Oct. 25
" " Lawrence Point Oct. 11
" " Pier 10 Brooklyn Sept. 29
Upper Bay Near Robbins Reef Light Oct. 16
" " " " " " 23
" " " " " " 24
Newark Bay " 6
Kill Van Kull " 4
Narrows Sept. 26
Complainants Exhibit No. 168
James D. Maher
Commissioner
N
72% - Oct. 16
74% - " 23
78% - " 24
ATLANTIC OCEAN
NEW YORK CITY
AND
VICINITY
SCALE OF MILES
0 1 2 3 4

Fig. 10

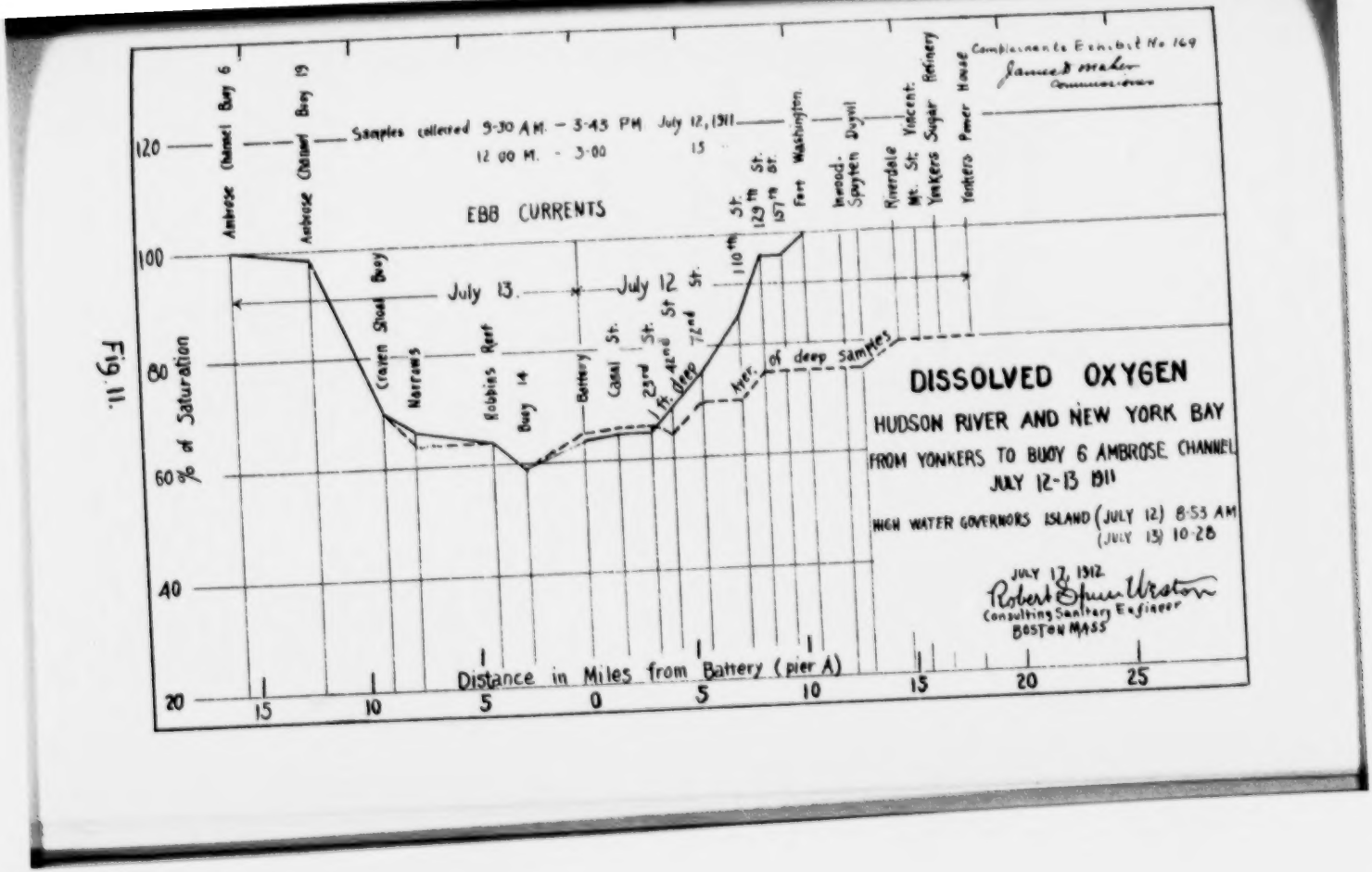

Complainants Exhibit No 169
James B Walker
Commissioner
Samples collected 9-30 A.M. - 3-45 P.M. July 12, 1911
12 00 M. - 3-00 " 13
EBB CURRENTS
Ambrose Channel Buoy 6
Ambrose Channel Buoy 19
Craven Shoal Buoy
Narrows
Robbins Reef
Buoy 14
Battery
Canal St.
23rd St.
42nd St.
Ft. 72nd Deep
110th St.
129th St.
137th St.
Fort Washington
Inwood.
Spuyten Duyvil
Riverdale
Mt. St. Vincent:
Yonkers Sugar Refinery
Yonkers Power House
July 13.
July 12
Incr. of deep Samples
% of Saturation
120
100
80
60
40
20
Distance in Miles from Battery (pier A)
15
10
5
0
5
10
15
20
25
DISSOLVED OXYGEN
HUDSON RIVER AND NEW YORK BAY
FROM YONKERS TO BUOY 6 AMBROSE CHANNEL
JULY 12-13 1911
HIGH WATER GOVERNORS ISLAND (JULY 12) 8-53 AM
(JULY 13) 10-28
JULY 17, 1912.
Robert Spurr Weston
Consulting Sanitary Engineer
BOSTON MASS

Fig. 11.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOW COMPLAINANTS' EXHIBITS Nos. 172, 173, 174, and 175.

Showing Results of Examination of Mud.

JAMES D. MAHER,
Commissioner.

Submitted by Olin H. Landreth
Sept 10. 1912 — 2a

PLE's Comments by Exhibit No. 172.
James D. Maher
Commissioner.

SUMMARY OF RESULTS OF EXAMINATION OF MUD DEPOSITS, MADE BY THE METROPOLITAN SEWERAGE COMMISSION SUBSEQUENT TO JAN. 1, 1908.
PREPARED BY OLIN H. LANDRETH

TABLE I — June, 1912

COLOR

District or Locality	No. of Sample Examined	Black	Gray	Brown	Yellow	Blue	White
1. Hudson River	115	42	46	21	3	1	
2. East River	55	39	14	2			
3. Harlem River	7	5	2				
4. Upper Bay	207	100	94	13			
5. Lower Bay	103	20	29	51			3
6. Newark Bay and Passaic River	111	50	56			5	
7. The Kills	28	22	5	1			
8. Jamaica and Gravesend Bays	21	13	8				
9. L. I. Sound, Hempstead, Pt. Chester, Pelham Bays	52	11	30	10	1		
0. Gowanus Bay, Newtown Creek	7	7					
1. Raritan Bay, Cheesequake Creek	6	6					
2. Atlantic Ocean	6			2	4		
3. The Narrows	9	4	3	2			
Totals	727	319	289	102	8	6	3

TABLE III.

Appendix No. 174

James L. Mahan Commissioner

Q U E R I E S

District of Locality	No. Samples	Sludge	Mud	Ooze	Clay	Sand	Gravel	Sub Soil
1. Hudson River	131	5	35		60	9	12	18
2. East River	76	34	15		22	4	2	1
3. Harlem River	7		7					
4. Upper Bay	655	195	45	2	256	140	14	65
5. Lower Bay	111		32		5	73	5	
6. Newark Bay, Passaic River	142	9	46		65	17	2	3
7. The Kills	48		32		1	10	5	
8. Jamaica and Gravesend Bays	27	2			17	6	2	
9. L. I. Sound, Hempstead, Pt. Chester, Pelham Bays	60	1	7		41	9	1	1
10. Gowanus Bay, Newtown Creek	7		5				1	
11. Raritan Bay, Cheesequake Creek	16		4		11		1	
12. Atlantic Ocean	2					2		
13. The Narrows	37	6			10	13	3	5
T o t a l s	1331	210	225	2	260	289	46	93

(Note:- The fact that the total number of samples examined (viz., 1331) exceeds the whole number of dredging is explained by the fact that in many cases a sample contained more than one substance.)

Complainant's Exhibit No 170
James Liddell
Commissioner

TABLE IV.

P O L L U T I O N

District or Locality	No. Samples	Polluted	Unpolluted	Doubtful
1. Hudson River	110	59	37	14
2. East River	61	56	4	1
3. Harlem River	7	7		
4. Upper Bay	409	282	130	87
5. Lower Bay		26	62	12
6. Newark Bay, Passaic River	103	65	32	6
7. The Kills	45	22	17	6
8. Jamaica and Gravesend Bays	32	12	7	3
9. L. I. Sound, Hempstead, Ft. Chester, Pelham Bays		10	47	2
10. Gowanus Bay, Newtown Creek	7	7		
11. Raritan Bay, Cheesequake Creek	7		2	5
12. Atlantic Ocean	6		6	
13. The Narrows	23	19	1	3
T o t a l s	1069	565	365	139

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 176.

Showing Results in Thames Dredging.

JAMES D. MAHER,
Commissioner.

17 Compliment Enclosed No. 176
James D. Mann
Commissioner.

THAMES DREDGINGS

Date of Collection (1906)	No.	Where Sample was Collected	Percentage Loss on Ignition #	Percentage of Nitrogen #	Probable Percentage of Sewage Sludge #	Remarks	Loss of Dissolved Oxygen caused by the sample in Tap Water saturated with Air at 60 degrees F.							
							Weight of Mud per Litre.		Hours of Contact	Dissolved Oxygen per Litre				
							Wet	Dry		Originally Present	After Period of Contact	Actual Loss	Percentage of Loss	
July 17	1	Barge House, North Woolwich	3.48	0.048	1.3	Coarse grey sand, showing a few black patches on keeping; odour like paraffin	---	---	---	----	----	----	----	
						Contained coal and cinders. On igniting scarcely blackened and no visible vapours	---	---	---	----	----	----	----	
"	2	Barking, near Outfall, North Side of Channel	11.69	0.388	13.9	Almost black mud; odour tarry; dried to a hard, grey cake, difficult to powder	12.5	4.38	3	5.77	1.74	4.03	69.8	2
						On igniting blackened and emitted odour with slight visible vapour	"	"	6	5.77	0.42	5.35	92.7	
"	3	Crossness, Half-way Reach, below Outfall	7.01	0.195	6.7	Almost black mud; odour tarry, dried to grey cake which powdered easily	12.5	3.32	3	5.77	3.27	2.50	43.5	3
						On igniting blackened and emitted odour but no visible vapour	"	"	6	5.77	1.35	4.42	76.6	
June 18	4	Greenhithe, North of Mid-Channel	11.76	0.382	13.7	Dark grey to black mud; no special odour dried to grey cake, difficult to powder	12.5	3.59	3	5.77	2.16	3.61	62.6	4
						On ignition blackened and emitted vapours with distinct odour	"	"	6	5.77	1.11	4.66	80.8	
"	5	Mucking, South of Mid-Channel	1.43	0.015	0.1	Coarse grey sand, showing a few black patches on keeping	----	----	-	----	----	----	----	
						On igniting only slight darkening and no visible vapour	----	----	-	----	----	----	----	
"	6	Chapman Light	1.34	0.015	0.1	Coarse grey sand, with some pebbles and shells. On igniting behaved like the Mucking sample	----	----	-	----	----	----	----	

On dry samples (see pp. 225-226).

1 COMPLAINANTS' EXHIBIT No. 177. James D. Maher, Commissioner.

In the Supreme Court of the United States, October Term, 1912

No. 5, Original.

THE UNITED STATES OF AMERICA, Complainant,
vs.
THE PEOPLE OF THE STATE OF NEW YORK and JOHN E. ANDRUS et al.

Motion to Dismiss Bill Without Prejudice.

Now comes the Solicitor General on behalf of the complainant in the above-entitled case, and filing herewith a stipulation between the parties by which a settlement of the questions involved has been made, which settlement provides in paragraph seven (7) that said stipulation shall be filed in this Court and that the bill of complaint be dismissed without prejudice, moves the Court to dismiss said bill of complaint without prejudice.

(Signed) WM. MARSHALL BULLITT,
Solicitor General.

December 2, 1912.

2 In the Supreme Court of the United States.

In Equity.

THE UNITED STATES OF AMERICA, Complainant,
against
THE PEOPLE OF THE STATE OF NEW YORK and JOHN E. ANDRUS, William Archer, and John J. Brown, as Commissioners of the Bronx Valley Sewer, Defendants.

Stipulation.

Two years before the Bronx Valley Sewer was completed to the margin of the Hudson River or in any way put into use, the United States instituted the above cause in order to prevent the further defilement of that stream by the discharge from said sewer. With full notice of the claims set up and relief asked therein, the Commissioners named as defendants caused the sewer to be constructed to a point beneath the waters of the river some 20 feet from the Eastern bank; and for a time they allowed sewage to be received into and discharged therefrom. Such use of the sewer was enjoined in a proceeding instituted in the Supreme Court of New York for the County of Westchester by the Leak & Watts Orphan House, &c., in June, 1911. The United States has continuously objected to the proposed sewer;

and at all times has refused to assent to the construction of the same beyond the bulkhead line unless and until adequate provision should be made for the purification of the effluent.

After this cause was instituted, the terms of office of Commissioners Andrus, Archer and Brown, terminated; and under the pro-
3 visions of Chapter 361, Laws of New York for 1911, the undersigned, Frank Jerome Hoyle, Henry C. Merritt and John L. Hayes, were appointed. The latter now constitute the full membership of the Bronx Valley Sewer Commission and may rightfully exercise all its powers.

In order to end the present controversy and to secure permission to complete the sewer beyond the bulkhead line as was originally contemplated, and with the desire on the part of the United States ultimately to bring about adequate purification of the Hudson River, the following stipulation and agreement has been entered into by and between the United States and Frank Jerome Hoyle, Henry C. Merritt and John L. Hayes, as members of the Bronx Valley Sewer Commission, acting in behalf of themselves and of their successors in interest and control:

First. The Bronx Valley Sewer Commissioners at once will begin the installation of a plant for the partial purification of the effluent of the Bronx Valley sewer system by screening and sedimentation with an efficiency sufficient to remove and which shall at all times remove from said effluent enough of its putrescible contents to purify the same to the extent of 10% upon an absolute putrescibility scale. This plant shall be completed and put into operation on or before the first day of May, 1913; and it or one not less efficient shall be kept in continuous operation producing at least the results above specified so long as the Bronx Valley sewer continues in use.

Second. At all times during the operation of the Bronx Valley sewer system, in addition to those specified in the paragraph immediately above, the requirements enumerated under the seven heads immediately following will be met either through the plant and installations above called for or through requisite additional arrangements:

(1) There will be absence in the Hudson River of suspended particles visible to the naked eye coming from the effluent of said sewer.

(2) There will be absence of deposits in the waters of the Hudson River coming from the effluent of said sewer which the Secre-
4 tary of War of the United States, exercising a reasonable discretion, may find objectionable.

(3) There will be absence in the waters of the Hudson River and its vicinity of any odor due to the putrefaction of organic matter contained in the effluent of said sewer which the Secretary of War, exercising a reasonable discretion, may find objectionable.

(4) There will be a practical absence on the surface of the Hudson River, at the dispersion area or elsewhere, of any grease or color due to the discharge of said sewage.

(5) There will be no public or private nuisance occasioned by the discharge from the said sewer.

(6) The effluent from said sewer shall not injuriously affect property of the United States situated in the Hudson River.

(7) There shall be excluded from the sewer all refuse matters of the classes forbidden by law to be discharged into the navigable waters of the United States.

Third. At any time subsequent to January 1st, 1917, or to the date when there shall be 50,000 persons contributing sewage to said sewer,—whichever date first arrives—the Secretary of War of the United States may designate a board of three men, which shall make inquiry into the pollution of the Hudson River by the presence therein of sewage, filth and refuse matter, and upon a view of the facts and circumstances thought to deserve consideration, this board shall determine and thereafter report to him what, if any, purification of the effluent of the Bronx Valley sewer, in addition to that specified in the foregoing sections of this stipulation and irrespective of what others in fact may be doing towards bringing about the end desired, ought to be required in order to impose upon said sewer, its managers and the territory served by it, the performance of their just, fair and equitable part of whatever may be necessary for the restoration and maintenance of the waters of the Hudson River to and in such degree of purity as will render them adequate for the support of the life of shad and other major fish.

After receiving the report of this board, the Secretary of War may, from time to time, direct such further degree of purification of the effluent of the Bronx sewer not in excess of the findings of the board as he may think proper; and within two years after receiving any such direction, the Bronx Sewer Commissioners or their successors in control shall cause the same to be brought up to the required standard.

The board of three appointed by the Secretary of War shall include one member designated by the Bronx Sewer Commissioners or their successors, provided he be named within thirty days after request therefor, and provided further that all expenses incident to his service shall be borne by those in whose behalf he is designated. A majority of the board may act and a report concurred in by two members shall be the report of the board.

Fourth. At all times hereafter, through such representatives as he may designate, the Secretary of War of the United States shall have full opportunity to inspect the construction of the proposed purification plant and the condition and working of the entire sewer system, in order to determine whether the terms and provisions hereof are being observed in all respects; and to this end the Commissioners will render such expert or other assistance as he may request. Said Secretary at all times shall have the right to decide whether such terms and provisions are being complied with; and upon notice from him that they are not, the Commissioners or their successors shall forthwith do whatever may be necessary in order to effect compliance herewith.

Fifth. Full compliance at all times with the terms and requirements of this stipulation shall be and remain the express condition of any permits issued by or on the part of the United States

for the construction and future maintenance and operation of the Bronx Valley sewer or any part thereof.

Sixth. This stipulation shall not become effective unless and until all such permits as may be requisite under the statutes of the United States for the construction, maintenance and operation of said sewer, according to the plans and specifications heretofore prepared, are actually obtained nor unless or until such permits are made conditional upon the compliance at all times with all the terms hereof.

Seventh. As soon as the permits contemplated in the section immediately preceding have been issued and this agreement, properly executed, has been filed in the office of the Clerk of the Supreme Court as a stipulation between the parties in the above-entitled cause, the United States will cause the bill of complaint to be dismissed, but without prejudice.

Eighth. Nothing herein contained shall hinder or interfere with the assertion or execution by the United States of their rights and powers granted by the Constitution or Statutes.

In witness whereof, this instrument has been duly executed in triplicate, being signed in the name and on behalf of the United States by the Attorney General and by all the members of the Bronx Valley Sewer Commission and being sealed also on behalf of said Bronx Valley Sewer Commission with its seal attested by its Secretary—all on the 17th day of July, 1912.

THE UNITED STATES OF AMERICA,
(Signed) By GEO. W. WICKERSHAM,
Attorney General.

[SEAL.] THE BRONX VALLEY SEWER COMMISSION,
(Signed) By FRANK JEROME HOYLE,
(Signed) JOHN L. HAYES,
(Signed) HENRY C. MERRITT.

Attest:

(Signed) JAMES J. SHAW, *Secretary.*

Endorsed: Supreme Court of the United States. The United States of America, complainant, against the People of the State of New York, and John E. Andrus, William Archer and John J. Brown, as Commissioners of the Bronx Valley Sewer, defendants. Stipulation. Supreme Court U. S., October Term, 1912. Term No. 5, Original. The United States of America, complainant, vs. The People of the State of New York et al. Motion and stipulation to dismiss bill of complaint. Filed December 2, 1912.

Exhibit 178



-HAVANA HARBOR-
HAVANA, CUBA.

"Limit of Area considered in Estimating Dilution."

COMPLAINANTS' EXHIBIT No. 178. James D. Maher, Commissioner.

Report upon Observations of the Pollution of Harbors of the Atlantic Seaboard by Sub-committee of Sub-committee Number 17 of the Experts for the State of New York in re Passaic Valley Trunk Sewer Project.

(Here follows map of Havana harbor.)

Nicholas S. Hill, Jr., Consulting Engineer, 100 William Street, New York.

Telephone 2053 John.
Water Supply.
Sanitary and Water Waste Investigations.
Fire Protection.
Water Power Development.
Filtration.
Pumping Stations.
Sewage Disposal.
Testing Laboratories for Analysis of Water, Analysis of Sewage, Analysis of Alloys, Testing of Coal, Testing of Sand, Testing of Cement.

Dr. W. J. O'Sullivan, Asst. Corporation Counsel, Hall of Records, City.

DEAR SIR: We respectfully submit our report upon the pollution of the harbors of those cities visited by your Committee during the month of December 1911.

The descriptions of the cities which follow are purely of an introductory nature, and are purposely made as brief as possible, and contain but very little data with relation to population, sewage flow, and information of like character, as all of these data, as well as other data relating to our investigations, are contained in the tables and statistics which follow.

General Description of Cities and Harbors.

Havana.

The City of Havana, Cuba, is built upon a peninsula and in relation to the Gulf of Mexico and its harbor, is located practically as shown on the accompanying map.

The old city, covering an area of some 1,500 acres, is but little above sea level, but the newer city and suburbs, covering about 4,500 acres, are hilly and reach, at some points, an elevation
2 of 130 feet above mean tide. The population is 360,000.

The waters of the harbor have a tidal range of about one foot between high and low water. The entrance to the harbor is through a narrow channel about 1,200 feet wide and about one mile in length. The area of the harbor is approximately 15,000 acres, giving a tidal displacement of approximately 65,000 cubic feet.

At the present time a complete system of sanitary sewers is being constructed for the entire city, which, when completed, will collect the sewage of the city and discharge it into the Gulf of Mexico at a point 4,000 feet east of Moro Castle in 30 feet of water.

At the present time the lateral system has been almost completed, and the sewage of the city, and suburbs tributary to the harbor, discharges through these new sewers and some old sewers that have not yet been intercepted.

At the time of our inspection, therefore, the sewage of the population tributary to the harbor was being discharged through outfalls along the water front. The aggregate population thus discharging sewage was, according to the estimate obtained from the Obras Publicas, approximately 87,000. Of this population, some 40,000 were discharging sewage through sewers at scattered points along the water front facing the main harbor, and where the tidal dilution and dispersion were relatively great.

The remainder of the population connected with sewers, approximating 47,000 people, were discharging their sewage into the
3 section of the harbor known as Atares Bay, an arm of the harbor lying at its extreme southwestern limit. Matadero Creek, St. Nicholas Creek, Dulce Creek, and other small creeks, draining a considerable portion of the suburban area of the city, empty into Atares Bay, and sewers of large size discharge into these.

It was to this latter section of the harbor, where objectionable conditions were very marked, that our observations and studies were largely restricted.

The accompanying map shows the location of the city with relation to that part of the harbor which was under observation.

The chief data relating to Atares Bay, as well as to portions of other harbors observed by us, are given in Tables Nos. 1 and 2, which follow.

The map shows the limits of pronounced and obnoxious visual sewage pollution, and the less marked but plainly visible sewage pollution.

(Here follows map of Baltimore harbor, page 4.)

Exhibit 178


Limit of Area considered in Estimating Dilution.
BALTIMORE
NORTH WEST HARBOR
PATAPSCO RIVER
-BALTIMORE HARBOR-
BALTIMORE, MD.

5 Baltimore.

The City of Baltimore, Md., is situated at the mouth of the Patapsco River, which empties into Chesapeake Bay, 160 miles from the Atlantic Ocean.

The city covers an area of approximately 19,200 acres, of which about 9,600 acres are densely built up. Its elevation varies from high tide at the docks to about 450 feet above mean low tide in the suburbs. Its population is 558,000.

The present sewer system consists of a number of storm water drains, entering into Jones Falls, Gwynns Falls, and the North West Harbor.

The sanitary sewage from about fifty per cent of a population of 290,000, in the more densely built up portion of the city, is carried by these drains into Jones Falls and the North West Harbor, with the result that they have become little better than open sewers, or cess pools, excessively offensive to sight and smell. The remaining fifty per cent of the population in the denser portions of the city here considered, is served by privy vaults and cess pools. The small per cent of population in other parts of the city connected to sewers, drains into Gwynns Falls and the Patapsco River.

The city is at present constructing an extensive system of sanitary sewers, designed to remedy the exceedingly bad conditions now obtaining in the North West Harbor.

The portion of the harbor and tidal area considered in this report in estimating sewage dilution is shown in blue on the accompanying map.

The tidal area of the North West Harbor is approximately 819 acres, and the tidal range is 1.2 feet. For details, see Appendix 1, Page 52.

(Here follows map of New York harbor, page 6.)

In this report, that portion of New York City and the surrounding communities is considered, the sewage from which empties into the Upper Bay. These communities are as follows:

Communities in the State of New Jersey Now Discharging Sewage ley Sewerage District.

Passaic County:

Paterson.
Manchester.
Prospect Park.
Hawthorne.
Aquackononk.
Passaic.

Bergen County:

Glen Rock.
Saddle River.
Midland.
Garfield.
Lodi Borough.
Hasbrouck Heights.
Woodridge.
Wallington.
Carlstadt.
East Rutherford.
Rutherford.
Union.
North Arlington.

Essex County:

Nutley.
Newark.
Belleville.
East Orange.
Bloomfield.
Glen Ridge.
Montclair.
Orange.

Hudson County:

Harrison.
East Newark.
Kearney.

Communities in the State of New Jersey, now Discharging Sewage Into the Hackensack River, Within the Metropolitan Sewerage District.

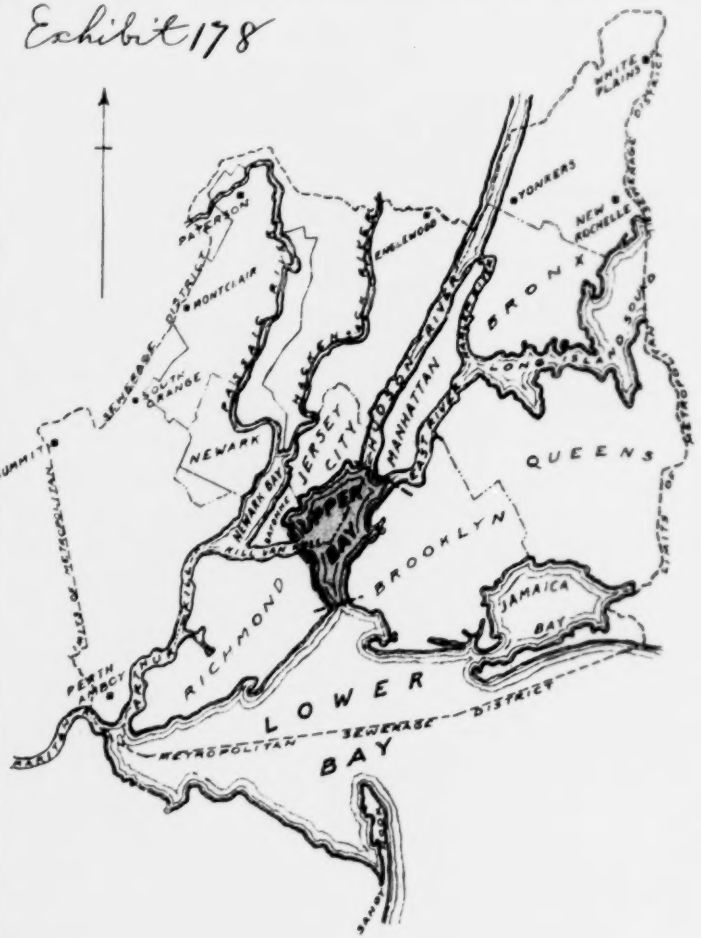
Hudson County:

Jersey City.
Kearney.
North Bergen.

Bergen County:

Fairfield.
Ridgefield.
Cliffside Park.
Palisade Park.
Maywood.
Lodi Township.
Hasbrouck Heights.
Little Ferry.

Exhibit 178



-·-·-·- = Limits of Area considered in Estimating Dilution.

-NEW YORK HARBOR-
NEW YORK, N.Y.

8 Bergen County (continued):

Leonia.
Englewood.
Teaneck.
Bogota.
Overpeck.
New Barbadoes.
Woodridge.
Carlstadt.
East Rutherford.
Rutherford.
Union Township.
North Arlington.

Communities in the State of New Jersey Now Discharging Sewage Directly Into Upper New York Bay, the Kill von Kull, and Lower Hudson River.

Bayonne.
Jersey City.
Hoboken.
West Hoboken.
Union.
West New York.
Weehawken.
Guttenberg.
Woodcliff.
Edgewater.
Fort Lee.
Englewood Cliffs.

Communities in the State of New Jersey Now Discharging Sewage Into Newark Bay and the Arthur Kill, Excluding the Passaic and Hackensack Rivers.

Part of Newark.
" " Bayonne.
" " Jersey City.
Elizabeth.
Roselle Park.
Irvington.
South Orange.
West Orange.
Millburn.
Perth Amboy.
Summit.
South Orange Township.
Union Township.
Rahway.
Fanwood.
Cranford.
Garwood.
Roosevelt.
Woodbridge.

Communities in the State of New York Now Discharging Sewage Directly Into Upper New York Bay, the East River, the Harlem River, and the Lower Portion of the Hudson River.

Yonkers.
White Plains.
Scarsdale.
Tuckahoe.
Bronxville.
Mt. Vernon.
Bronx Borough.
Manhattan Borough.
Part of Brooklyn Borough.
" " Queens "
" " Richmond "

Communities in the State of New York Now Discharging Sewage Directly Into Newark Bay and the Arthur Kill.

Part of Richmond Borough.

It has been assumed that 80 per cent of the population within these communities contributes domestic sewage to the various drainage systems.

As it has been determined by the United States Coast and Geodetic Survey, and so reported by the Metropolitan Sewerage Commission, and the Central Committee of Experts for the State of New York that approximately 84 per cent of the water entering Newark Bay finds its way through Kill Van Kull into Upper New York Bay, the remaining 16 per cent going through Arthur Kill into Lower New York Bay, we have, for the purpose of estimating, assumed that but eighty-four per cent of the sewage, draining into the Passaic and Hackensack Rivers and into Newark Bay, reaches Upper New York Bay.

In other words, we have considered that all of the sewage which enters the Hudson and East Rivers, and Upper New York Bay, together with eighty-four per cent of the sewage reaching the Passaic, the Hackensack and Newark Bay, is contributary to Upper New York Bay. If the Passaic Valley Trunk Sewer is constructed, then, of course, one hundred per cent of the sewage from the Passaic Valley Sewerage District will be delivered directly into the Upper New York Bay in the vicinity of Robbins Reef Light.

The elevation of the district considered varies from high tide at the docks to about three hundred feet above mean tide in East Orange and White Plains.

The sanitary and combined sewers within this district discharge directly into the streams or bays tributary to the Upper New York Bay, or into the Bay itself. Many outlets are under piers at the bulkhead line. These outlets are so numerous, however, that it is impossible to show them in the accompanying map, which displays the boundary of the district contributing sewage and the tidal areas considered in estimating dilution. For the purpose of estimating the dilution we have taken the total quantities of new sea and land water available in Upper New York Bay as explained in the Appendix.

(Here follows map of Potomac River at Washington, D. C., page 10½.)

Exhibit 178



- POTOMAC RIVER -
AT
WASHINGTON, D.C.

11 Washington.

The City of Washington is situated on the north bank of the Potomac River 156 miles from the entrance into Chesapeake Bay, and 185 miles from the Atlantic ocean. The Potomac at this point is quite a bold stream, draining an area of over 11,000 square miles.

The city has an area of approximately 6,400 acres tributary to the sewage system. It rises from the river level to an elevation of about 90 feet above mean tide. Its population is 343,000.

The city is almost completely sewered and is served with an extensive general system of combined sewers. The sanitary sewage of approximately 308,000 people is taken care of by the general sewerage system and is pumped to an outlet near the east bank of the Potomac River, three miles below the city, to which point the storm water drainage is also pumped.

The sewers in certain small districts discharge directly into the Potomac at several points along the water front.

The outlet of the general sewerage system consists of two 60 inch pipes, opening vertically at a depth of 28.7 feet below mean high tide, and at a distance of 750 and 800 feet respectively from the river bank. The location of these outlets is indicated by a red dot upon the accompanying map. The sewer outlet is carried well out into the main shipchannel where the currents in the river have the greatest velocity.

12 Washington is located at the head of tide water, the tidal range being 2.9 feet. The fresh water dilution is so great that the sewage may be considered to empty into a fresh water stream.

Notwithstanding the very slight difference in density of the sewage and river water, the vertical rise of the sewage was rapid, judging from the surface effects, at the time of our visit, and although the sewage was partially screened, the visual evidence of the sewage in the form of particles of feces, match sticks, paper, etc., were apparent for a mile or more north of the outlet. The observed sewage field is indicated on the accompanying map. The turbidity of the Potomac water at the time the observations were made was sufficient to materially lessen the visual effects which would result in clear water.

The observations herein reported were limited to a study of the outlet just described, and the estimated tidal dilution is considered to be the average annual daily fresh water flow of the Potomac River at this point.

(Here follows map of Tampa harbor, page 13.)

14

Tampa.

The City of Tampa, Florida, is situated at the northern extremity of Hillsboro Bay, the eastern arm of Tampa Bay on the west coast of Florida, and 35 miles from the Gulf of Mexico.

The main outlet of the sewer system is a horizontal pipe, six feet in diameter, opening at the edge of a dock near the mouth of the Hillsboro River and nine feet below mean tide. This outlet delivers the sewage of about 10,000 people of a total of 13,000 connected with sewers in the City of Tampa.

There are two other outlets emptying into the Hillsboro River, which serve approximately 3,000 people.

Our observations were confined practically to the main outlet.

The limits of the tidal area considered are shown on the accompanying map. This area is approximately 134 acres. The tidal range is two feet.

The conditions of the main outlet in Tampa were peculiarly interesting as they offered an excellent opportunity for observing the rapid rise of fresh water sewage in strongly saline waters. The salinity of the water near the point of the main outlet was 14,409 parts per million.

The sewage flowing from this outlet rose at once to the surface, boiling up above the surface of the surrounding water, forming a mushroom shaped mound, distributing sewage over an area ten feet in diameter, which floated down stream on the surface of the tide, spreading out in fan shape, as it progressed downstream.

15 For a distance of 100 feet below the outlet, the water showed a very marked sewage color, and had an offensive odor and marked discoloration, and more or less dissipated floating feces and sewage matter were noted at a distance of 750 feet below the outfall.

(Here follows map of Boston harbor, page 16.)

Exhibit C 178



-TAMPA HARBOR-
TAMPA, FLA.

Exhibit 178



-BOSTON HARBOR-
BOSTON, MASS.

LEGEND.
● = Sewer Outfalls.-
= Limits of Area considered in Estimating Dilution.-
D = Approximate Zone of Visible Pollution.

17 **Boston.**

The City of Boston, Mass., is situated at the mouth of the Charles River, at the head of Boston Harbor on the coast of Massachusetts.

The territory about Boston, considered in this report, comprises the "Boston Metropolitan Sewerage District" and the "Boston Main Drainage District," and has a total area of approximately 206 square miles. Its elevation varies between the tide water at Boston, and 500 feet above mean tide at the headwaters of the Charles River.

The sewage from the densely built up portion of Boston is collected by the sewers of the "Boston Main Drainage System," and is pumped to tanks on Moon Island, where it is stored until the tide is ebbing, when it is discharged into the harbor, producing a clearly marked area of greasy, sewage colored water. The sewage from the surrounding communities is collected by the sewers of the "Boston Metropolitan Sewerage District." This sewage is discharged into the harbor at Deer Island and Peddock's Island, as indicated on the accompanying map. This map displays also the tidal area considered in estimating sewage dilution and the limits of the "Boston Metropolitan Sewerage District" and the "Boston Main Drainage District." It also indicates the visual field of sewerage pollution as derived from the report of the Massachusetts State Board of Health for the year 1900.

Boston Harbor has been the subject of much study by the Massachusetts State Board of Health, a special report having been made thereon in 1900 by Mr. Goodnough as Chief Engineer.

18 Again, in 1905 Mr. Goodnough made a second report, as published in the Report of the Massachusetts State Board of Health for that year.

The facts which are given in this report are largely quoted from the data contained in the two reports of Mr. Goodnough and from the published reports of the Metropolitan Water and Sewerage Board for the years 1905 and 1910.

Your Committee did not visit Boston, but the facts as set forth have been collected for the purpose of comparing conditions in Boston with those in New York Harbor.

(Here follows map of Savannah River at Savannah, Ga., page 19.)

20 Savannah.

The City of Savannah, Georgia, is situated on the south bank of the Savannah River, 18 miles from the mouth.

That portion of the city tributary to the sewer system covers an area of 1,220 acres, and includes the densely populated sections.

It is built upon low land, its highest point having an elevation of but 52 feet above mean low water in the river. One half of the area of the city has an average elevation of only 35 feet above mean tide.

There are 51 miles of sanitary sewers, emptying into the Savannah River at two points. The principal outlet is at Gordon's Wharf and is a 30-inch horizontal pipe ending at the wharf line and 13 feet below mean low water. These sewers serve only about three-quarters of the population. The remainder use privy vaults and dry closets. At the present time, however, there is a movement on foot to extend the sewer system to the outlying districts.

An examination of the river at Savannah during flood tide on January 12, 1912, showed no visual evidence of sewage pollution, the river appearing generally clean, though turbid.

Of all the harbors visited by your Committee, Savannah afforded the best opportunity of studying the effects of turbidity upon the visual surface nuisance to be observed in the vicinity of sewer outfalls. It was plainly evident that high turbidity appreciably reduced visual effects, so much so that it was difficult to observe the sewage immediately at the outfall at high tide. The high turbidity of the water in the Savannah River, coupled with its low specific gravity, accounts for this condition.

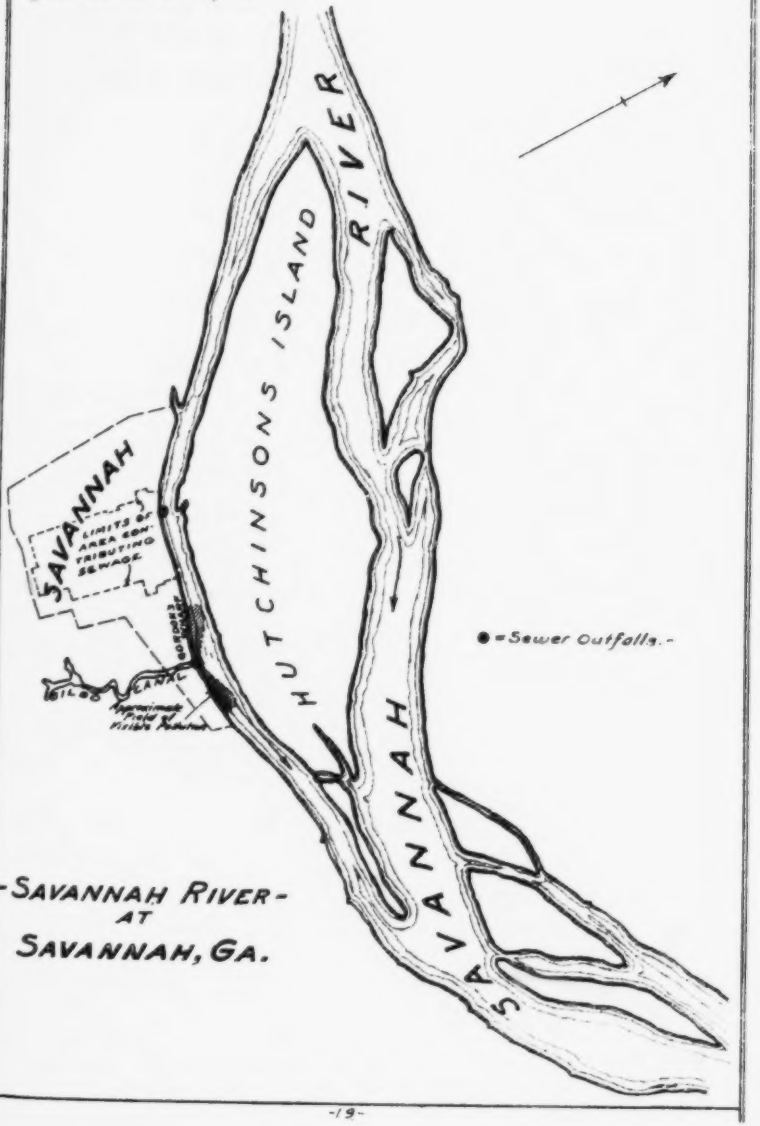
21 The salinity of the water here, as in Washington, is very low.

At slack tide, the sewage rises to the surface at a point 50 feet north of the pier line, and on ebb tide evidences of the sewage were observed for a distanc of 1,600 feet down stream from the outlet.

The owner of the boat from which these observations were made, as well as a fore man on the wharves, stated that under the piers, in summer, the stench of sewage was very noticeable for an appreciable distance each side of the sewage outlet.

The tidal velocity in this stream is very high at the center of the river, and, as has been observed, in the case of New York Harbor, the tidal velocity along the shore lines is very much reduced by the piles and other obstructions sustaining the piers. The result is that in Savannah, as in New York, the sewage flows in a line parallel with the axis of the river and hugs closely to the shore. Under these conditions, it is but natural that there should be a heavy deposition of suspended matter under the piers, and no doubt, if the Gordon Street outlet could be observed in warm weather, septic action of the bottom mud would be noticed for an appreciable distance each side of this outlet.

Exhibit 178



-SAVANNAH RIVER-
AT
SAVANNAH, GA.

The accompanying map shows the location of the sewer outlets. Savannah, as in the case of Washington, was considered as having only that dilution produced by the fresh water flow of the river. The Savannah River drains an area of approximately 11,000 square miles above its sewer outlet.

(Here follows map of St. John's River at Jacksonville, Fla., page 22.)

23 Jacksonville.

Jacksonville, Florida, is situated on the north bank of the St. John's River at a bend 22 miles above its mouth. The St. John's drains an area of 8,143 square miles above Jacksonville.

The city is not closely built up, and covers a considerable area at an elevation of from 0 to 43 feet above the river.

There are sixty-seven miles of sewers, principally sanitary, leading to eight outfall sewers, as follows, reading from east to west on the accompanying map:

Fairfield Outfall.
Georgia Street.
Catherine "
Market "
Main "
Cedar "
Stonewall "
Osceola "

At the Fairfield outfall, the sewage is pumped out under head. To the others, the sewage flows by gravity to outfalls at a depth of from 4 to 20 feet below the water in the river and are horizontal with the exception of the Market Street and Stonewall Street sewers, which are turned down. In size, they range from 8 to 24 inches in diameter.

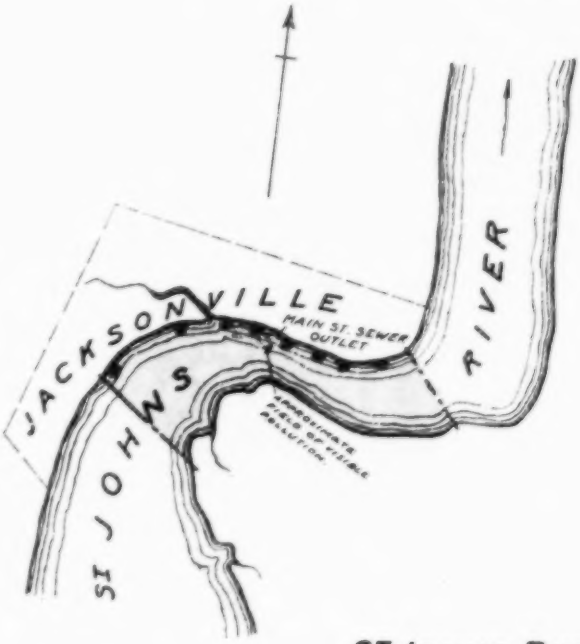
These sewers serve about one-half of the population, the remainder being provided with privy vaults or dry closets.

The position of these outlets is indicated at ebb tide by an area of discoloration of the river water, and at the Main Street outlet by noticeable boiling. At the Catherine Street outlet, which was located at the pier head, there was visible evidence of septic action in the bottom mud for an area one hundred foot square, to-
24 gether with a distinct sewage odor, though the temperature of the water at the time of inspection was but fifty-five degrees.

Our observations at Jacksonville were confined chiefly to the Main Street sewer, the largest and most important of the local sewers. This sewer discharges about three million gallons daily. It has a 24 inch horizontal outlet placed about 20 feet below mean tide. The sewage was plainly visible at the surface and the visible sewage field adjacent to this sewer is indicated on the accompanying map. The map also shows the limits of the tidal area considered in estimating the dilution at Jacksonville.

(Here follows map of Charleston harbor, page 25.)

Exhibit 178



St Johns River
at
Jacksonville, Fla.

-LEGEND-
● = Sewer Outfalls.-
—·—·— = Limits of Area considered in estimating Dilution.-


Exhibit 178
APPROXIMATE FIELD OF VISIBLE POLLUTION
GADSDENS CREEK
ASHLEY RIVER
CHARLESTON
COOPER RIVER
HARBOR
- LEGEND -
• = Sewer Outfalls -
= = Limits of Area considered in Estimating Dilution -
- CHARLESTON HARBOR -
CHARLESTON, S.C.

-TABLE Nº 1.-

-LAND WATER FLOW, TIDAL RANGE, TIDAL AREA CONSIDERED AND CHARACTER OF HARBOR WATERS.-

- City. -	Drainage Area Contributing Land Water (Sq. Mi.)	Annual Rainfall (Inches.)	Run Off (Per Cent of Rainfall)	Fresh Water Flow. (Mi. Cu. Ft. in 12 hrs.)	Tidal Range (Ft.)	Tidal Area Considered (Acres.)	- Character of Harbor Waters. - Temperature of Water (Degrees F)	Salinity. -	Turbidity.	Dissolved Oxygen. (% Saturation)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Havana.	4.3	50.00	28.07.	0.2	1.0	175	75°F	18,500	20	94.9
Baltimore.	47.0	50.88	36.0 -	2.8	1.2	819	41 -	4,500	25	84.4
New York.	14,571.0			*1180.0	4.4	13,274		11,916		30.0
Washington.	11,043.0	36.86	39.0 -	500.0	2.9	0	42 -	6	75	97.0
Tampa.	602.0	53.73	40.0 -	41.2	2.0	134	65 -	14,400	40	90.0
Savannah.	11,100.0	50.00	42.2 -	430	7.0	0	50 -	150	100	90.0
Charleston.	1,622.0	48.73	40.0 -	103.0	2.7	3,900	54 -	17,000	18	91.0
Jacksonville.	8,143.0	53.75	40.0 -	556.0	3.5	1,842	54 -	3,300	19	88.0
Boston.	662.0	45.68	48.5 -	46.6	10.0	28,900				

* New Land Water available for Dilution; from "Brief Report on Tidal Actions in the Harbor of New York", by Mr. N. de B. Parsons.-

(Exhibit No 178)

TABLE Nº 2.
POPULATION AND ESTIMATED VOLUME OF SEWAGE.

City	POPULATION OF CITY OR AREA CONSIDERED - 1940			VOLUME OF SEWAGE				
	Total	Contributing Sewage	Per cent Contributing Sewage	Domestic & Mfg. Wastes from public sources per cap. per day	Mfg. Wastes from private sources per cap. per day	Infiltration per capita Gal. Daily	Total Sewage per capita Gal. daily	Gross Sewage Millions of cubic feet per 12 hours
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Havana	360,000	47,000	13 %	125	0	50	175	0.55
New York - 1940	12,000,000	9,600,000	80 %	130	20	50	200	128.00
Baltimore	558,000	145,000	26 %	121	10	50	181	1.75
New York - 1910	6,000,000	4,800,000	80 %	113	10	50	173	55.40
Washington	343,000	308,700	90 %	—	—	—	218	4.50
Tampa	37,382	13,300	36 %	125	0	50	175	0.16
Boston	1,371,000	1,165,000	85 %	—	—	—	175	13.60
Savannah	67,000	49,000	73 %	153	0	50	203	0.66
Jacksonville	60,000	35,000	58 %	83	0	50	133	0.31
Charleston	59,000	19,700	33 %	87	0	50	137	0.18

26

Charleston.

The City of Charleston, South Carolina, is situated on the southern point of a low peninsula washed on the east by the Cooper River, and on the west by the Ashley River. To the south, Charleston Harbor extends 6 miles to the Atlantic Ocean.

The area of the built-up portion of the city is 7,680 acres, and its average elevation is about 15 feet above mean tide.

The sewer system at the present time consists chiefly of certain tidal drains to which connections have been made by a small number of houses. In the southern end of the city there are about five or six miles of sanitary sewers, which are now in use. The city is at present, however, engaged in the construction of a general system of sanitary sewers.

The total number of houses in Charleston is approximately from eight to ten thousand, and the number of privy vaults, or dry closets, five to seven thousand, so that possibly not more thar three thousand houses are connected up with existing sewers and drains.

The sewer system will comprise some fifty miles of sanitary sewers, which will empty into the Ashley and Cooper Rivers along the water front.

At the time of our inspections no evidence of pollution was observed in the harbor, except local nuisance in the immediate vicinity of the outlets.

The tidal drain leading into Gadsden Creek was closed at the time of our visit. This creek drains a large marsh, and in going through the marsh in a row boat, the visual evidences of
27 sewage pollution were very marked and there was an appreciable odor of sewage everywhere prevalent. No doubt, this marsh is a source of considerable nuisance in warm weather.

This condition offers a very excellent illustration of the broad local nuisance produced by emptying sewage, even in small amounts, into shallow waters exposed to the full effects of the sun, a condition which was brought prominently to attention on the old Potomac flats prior to the reclamation of the island now forming Potomac Park, and the construction of the main sewer outfall at its present location three miles below Washington. Formerly, the sewage of Washington was carried into the Potomac River at various points along the shore front, and on the flood tide would spread upon the flats where the suspended matter was quickly deposited. With the receding tide, this organic matter was exposed to the influence of the sun, the result being that the foul smelling odors carried by southerly winds were plainly marked at distances as far north as the White House.

The accompanying map shows the location of sewer outlets and the area considered in estimating dilution.

(Here follow Table No. 1 and Table No. 2, pages 28 *a* and 28 *b*.)

29 Relative Effects of Pollution in Different Harbors.

Basic Data.

Tables Nos. 1 and 2 give in condensed form the basic data from which Table No. 3, which follows, was compiled. The basic data for, and explanation of Table No. 1 will be found in Appendix No. 1 and similarly for Table No. 2 in Appendix 2.

Table No. 3 shows the relative degree of pollution in the various harbors considered in the report, the resulting dilution, the per cent of saturation of dissolved oxygen, and the putrescibility of the harbor mud, together with an estimate of the number of tons of wet sewage sludge per million cubic feet of total water (fresh and salt) available for dilution.

Averages Used.

For the purpose of avoiding complication, and in order to obtain a clear conception for a broad general estimate of the permissible pollution of harbors, figures for average tidal range, average rainfall and runoff, and average sewage flow have been used throughout.

Dilution.

The sea water available for dilution (Col. 5, Table 3) in Upper New York Bay is the new sea water which does not return on the next succeeding tide as computed by Mr. H. de B. Parsons in his brief report on "The Tidal Actions in the Harbor of New York." The figures given by Mr. Parsons are substantially those used by the Metropolitan Sewerage Commission. To this was added the new land, or fresh water, as estimated by the same authorities, and approved by the Central Committee Experts.

(Here follows Table No. 3, page 29½.)

(Schedule No. 9 (1))

TABLE No. 3.

RELATIVE EFFECTS OF SEWAGE POLLUTION IN VARIOUS HARBORS.

Harbor	(Local Water) Surface Area in Square Miles of Area in 12 Hours	Rate of Sewage Influx in Millions of Gallons per 12 Hours	Resulting Local Water Dilution	Sea Water Conveyed Available for Dilution in Millions of Gallons per 12 Hours	Total Dilution Assumed as (Local Water Dilution) plus (Sea Water Dilution)	Dissolved Oxygen % Saturation	Permeability of Harbor Mouth (Miles)	Mid Shore Tides per Day	Mid Shore hours per Day of Flood per Cent
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
HAVANA	0.5	0.55	1: 09	6.0	1: 11	0.0	1: 2200	66	44.6
NEW YORK (1907)	180.0	138.00	1: 9	2340.0	1: 26			18972	6.0
BALTIMORE	25	1.75	1: 14	43.4	1: 20	23.4	1: 834	304	6.0
NEW YORK (1910)	180.0	55.4	1: 21	2340.0	1: 61	67.0	1: 720	8436	3.4
WASHINGTON	30.0	4.5	1: 111	0.0	1: 111	82.0		492	1.3
TAMPA	41.2	0.16	1: 258	11.7	1: 330	80.5		19	0.5
BOSTON	48.6	13.6	1: 3.4	12000.0	1: 930			1830	0.2
SAVANNAH	70.0	0.06	1: 1124	0.0	1: 1124	86.0	1: 13	69	0.1
JACKSONVILLE	55.0	0.31	1: 1790	282.0	1: 2304	88.6		44	0.1
CHARLESTON	10.0	0.18	1: 572	53.6	1: 3624	96.0		28	0.1

30 The method of estimating the quantity of water available for dilution used by Mr. H. de B. Parsons, is as follows. See his "Brief Report on the Tidal Actions in the Harbor of New York."

"The quantity of 'new' sea water entering Upper Bay is:

	In million cubic feet per tidal cycle.
At the Narrows—Average for year	2,210
Least amount—(February)	670
Least amount—(Summer—August)	1,520

"These figures were determined,

1st. From observation of the total tidal flow through the Narrows at ebb tide.

2nd. From daily observation by the salinometer, the records covering a period of over one year as made by the Metropolitan Sewerage Commission. The average of these observations is appended.

"If no land-water entered the harbor, then the water in the harbor would be as salty as that of the sea. The mean quantity of water flowing on ebb tide was divided into land and sea-water by means of the salinometer percentages. The land-water was then divided into 'land-water which will return' and 'land-water which will not return.' The latter was taken as the run-off of the rivers for 12 lunar hours and the former as the remainder of the total land-water as shown by the salinometer.

"The sea-water, as shown by the salinometer was then divided by making the 'sea-water which will not return' the same proportion of the total sea-water as the 'land-water which will not return' is to the total land-water. This is so because the land and sea-water are mixed, and the amount of 'land-water which will not return' will take with its proportionate amount of sea-water.

"The division of water on flood tide was made by taking the total volume of flow on flood and laying off the amounts of land and sea water which will return as shown on ebb. The remainder is the 'new' sea water, or the water which was not in the harbor on the preceding tide. It must be equal to the 'sea water which will not return' as given on ebb.

"The land water as shown by the salinometer is always in excess of the runoff. This is so because the flushing action of the harbor is not complete, as at the end of every ebb tide there remains some land water in the harbor. The amount remaining, which is the amount in excess of the run-off, is variable, due to the seasonal variations."

31 To obtain the amounts of sea and land water which return on succeeding tides, and which is, therefore, not available for dilution, but which may be considered as dead water, swinging back and forth, and which is ultimately displaced by the sewage requires float or current meter measurements to determine the average velocity of the tidal movement in each tidal cycle, the observations being made at some point of known cross section. Such

measurements were obviously impossible in the time available for the work of this Committee, and, therefore, the sea water available for dilution, to be added to the computed land water available for dilution, has been determined by taking the tidal prisms in the assumed tidal areas, affected in each harbor, as shown on the maps of Harbors, Pages 1 to 25.

At Washington and Savanah, the chlorine content in the harbor water was so low as to indicate that the total available dilution was due entirely to the fresh water flow.

At Baltimore, the change in the amount of chlorine in the upper end of the North West Harbor and in the Patapsco River, outside of this harbor, was so slight as to indicate that the fresh water flow was but a very small per cent of the total water available for dilution. Sufficient data were not at hand, however, to determine precisely the relative average salinity of the water in the upper end of the North West Harbor and in the Patapsco River outside of this Harbor for the purpose of cumputing the exact ratio of fresh water to sea water. Under these circumstances, the volume of the tidal prism comprised within the limits of the North West Harbor was taken as the total available water for dilution. As this harbor is a dead end harbor, the tidal prism probably gives a fair rational basis
32 of estimate, and probably a greater dilution than actually occurs. The resulting dilution of 1 to 26 falls where it should, when the conditions obtaining in Baltimore are compared with those of Havana on the one hand, and those of New York on the other. Moreover, Baltimore Harbor is so putrid that it has evidently passed considerably beyond the critical point, and even should the estimated dilution be somewhat high, there would be a big mârgin between the true dilution at which general nuisance will occur and the dilution as estimated for Baltimore.

Comparisons made in Jacksonville, between an estimate of the total available dilution based on the assumed tidal prism and one based on salinometer percentages, were found to accord closely.

At Havana, the same method was used as at Baltimore, with comparable results. At the other places, the dilutions were so great that a slight error in stating the total sea water available for dilution would not materially affect the results.

The results given, therefore, should give a fair expression of the actual conditions as to total dilution, and as the range of difference in the resulting dilution in the various harbors is so great, no serious inaccuracy in making general comparisons is introduced.

Some criticism may be made assuming the tidal area of New York as that of Upper New York Bay. This will make no practical difference in the final results. So long as the assumption of the amounts of new land and sea water available for dilution are even approximately accurate, the only effect of extending the tidal area considered so as to include the Hudson and East Rivers, Kill von Kull
33 and Newark Bay, will be to increase the stored water volume available for dilution. Below mean low water there is a fixed amount of water requisite to fill the depressions constituting, when filled with water, the various bays and rivers. This dead

water, or stored water, is continually replaced, or renewed, by tidal and land water flow. If, then, the tidal and land water flow were excluded and sewage in amount of that now emptying into the various tributaries to Upper New York Bay were allowed to enter into these basins, it would gradually replace all of the stored or dead water in those basins. If, then, the tidal and land flow were allowed to enter again, the dilution would result only from such flow. The only effect, therefore, of extending the tidal area is to increase the amount of stored water and to somewhat delay the date at which net dilution will obtain. As the process of emptying sewage into streams, rivers and bays tributary to Upper New York Bay is a continuous one, and has continued for many years past, it is safe to assume that the net dilution now effected is the ratio of the new sea and land water passing through the Bay to the sewage passing therethrough. The detailed explanation of the manner of determining these factors for New York is found on Page 30 of this report.

Standards of Purity.

In an attempt to establish some simple standard, limiting the amount of sewage which may be safely discharged into a stream, or tidal estuary, without producing putrefactive nuisance, an effort has been made to fix upon the minimum allowable dilution of the sewage which will result from discharging it into a body of water.

34 From observations made by Stearns, Hering and Goodnough, the proportion of sewage which can be safely discharged into a stream may be expressed as follows:

Nuisance Probable	1 in 16 to 1 in 23
Nuisance Improbable	1 " 36 " 1 " 45

Roughly speaking, then, a stream may be able to purify one-fiftieth of its volume of sewage, but not one-twentieth. These conclusions were drawn with relation to fresh water streams. Whether or not sea water will absorb more sewage than land water, without producing nuisance, has never been practically determined, but it is worthy of remembrance that sea water, when saturated with oxygen, contains about 20 per cent less oxygen than land water at like temperatures. From this fact alone it seems probable that, for like quantities, land water will dispose of more sewage than sea water.

However this may be, the data presented in Col. 6, Table 3, show clearly that with a dilution of 1 in 26, as in Baltimore, general nuisance will result. The "basin" at the upper end of the North West Harbor in Baltimore is little better than an open cess pool in which septic action is active and from which foul odors emanate. It is no exaggeration to say that the whole North West Harbor is in a state which makes it an injurious nuisance.

Havana furnishes another example of a like nature where the dilution is placed at 1 in 11.

Everyone is more or less familiar with the present conditions in New York Harbor, which are described in detail in several volum-

inous reports. It is sufficient to say that conditions here have not yet reached the acute stage. The results of our observations, therefore, indicate that with an available dilution of one in sixty,
35 a harbor will reasonably, though not perfectly, digest the sewage emptying into it, but will not do so with a dilution of one in twenty-six. This estimate accords reasonably well with Stearns, Hering and Goodnough, especially so, if the difference in the oxygen content of land and sea water is considered.

Estimates of the sewage tributary to Upper New York Bay in 1940 indicate that the dilution will be reduced at that time to 1 in 26 (Col. 6, Table No. 3) or the same as at present in Baltimore.

The general conclusion to be drawn from this statement is that the New York Harbor is fast approaching the limit of its capacity to digest sewage without resulting general nuisance.

Of course, it must be remembered that the use of dilution ratios as a means of fixing a standard for harbor pollution is, at best, misleading, insofar as it does not express in any way local nuisances which may result to the detriment, not only of property, but of health in the vicinity of sewer outlets. Dispersion and diffusion are so intimately associated with the results to be obtained from dilution that no specific statement of the effect of dilution can be made without knowledge of local conditions.

On the other hand, the amount of dilution does furnish an extended view of general conditions and is of assistance in pointing to general conclusions. It is useful so far, and no farther.

Dissolved Oxygen.

The percentage of saturation of dissolved oxygen in the water of various harbors, as shown in Column 7 of Table No. 3, in-
36 dicates that it follows, in a general way, inversely as the degree of pollution. In other words, the greater the pollution, the smaller the amount of dissolved oxygen. The figures given are interesting in fixing the probable limits to the amount of dissolved oxygen requisite in harbor waters.

Theoretically, while any dissolved oxygen remains in a water, there should be no putrefaction. As a matter of fact, it has been recognized by authorities at home and abroad that malodorous conditions due to putrefactive action may take place long before the oxygen content of a water has been completely exhausted. The degree of oxygen saturation requisite to prevent malodorous conditions varies with many factors, and opinions on the subject differ widely. At best, this method of gauging permissable pollution, when considered alone, is unsatisfactory, but it may be useful in conjunction with other standards in establishing broad lines of differentiation.

In Baltimore Harbor, with an average dissolved oxygen content of practically 23, marked evidences of putrefactive action were apparent all over the harbor, notwithstanding that the temperature of the water at the time of examination was about 46° F.

In Upper New York Bay, the percentage of saturation of dissolved oxygen is 67, and there are no general evidences of septic action,

such as exist in the North West Harbor at Baltimore. The results of these observations indicate that if the average percentage of saturation of dissolved oxygen in a harbor water falls somewhere between these limits, the nuisances resulting from putrefactive action will follow.

37 Local nuisances near the sewer outfalls may exist, however, in harbors where the average dissolved oxygen content is much higher than the figures just mentioned. At Jacksonville, where the lowest percentage of dissolved oxygen recorded was about 64 per cent, there was evidence of local putrefactive action in the vicinity of several of the sewer outfalls. The same conditions were noted at many other places.

Putrescibility of Harbor Mud.

Unfortunately, as shown in Column No. 8, Table No. 3, your Committee was able to obtain samples of the bottom mud from the harbors of but few of the cities visited. A comparison of the analyses of those samples collected, however, as well as of analyses of bottom mud from lakes and ponds of known purity, as shown in the Table giving the results of "Quantitive Putrescibility Tests on Mud", (Appendix No. 1, Page 69) shows that the degree of putrescibility of harbor muds corresponds generally with the degree of pollution. In Atares Bay, Havana Harbor, where the dilution was least and the dissolved oxygen was exhausted, the mud was putrescible when diluted in twenty-two hundred times its volume of distilled water, in Baltimore Harbor in eight hundred and thirty times its volume of distilled water, while the Massapequa Pond mud was only putrescible when diluted one to seven.

It is to be regretted that quantitive putrescibility tests on the mud of New York Harbor were not carried on by the Metropolitan Sewerage Commission, as such tests may serve as an additional index in fixing upon the permissable limits of the pollution of harbors. They are especially interesting in relation to the development of local nuisances. Every additional slant on this important question is useful, for, with the many varying factors and

38 changing conditions in every harbor, detailed data accumulate rapidly, and one's sense of perception is clouded in a mass of figures and correct conclusions are obscured unless simple tests and simple lines of study are adhered to. It is only upon broad general conclusions that the safe permissable degree of pollution of any harbor can be settled. The problem does not lend itself to refined scientific diagnosis. Broad comparisons along different lines are essential to a conclusion, and quantitive putrescibility tests on mud give a simple additional line of evidence.

Tons of Wet Sludge per Million Cubic Feet of Water Available for Dilution.

Column No. 10 of Table No. 3 gives the tons of wet sludge which will be produced by the estimated amount of sewage (Column No. 3) which will enter into the various harbors listed.

It is seen that the quantity of wet sludge varies in general inversely as the estimated total dilution (Column No. 6).

The amount of wet sludge produced, thus expressed, gives another simple way of gauging the permissable density of pollution, and entirely removes the factor of sewage strength, as the estimates of the quantity of wet sludge have all been reduced to a population basis. (See Appendix No. 3).

It is seen that 14-6/10 tons of wet sludge per million cubic feet of total water available for dilution are delivered into Atares Bay at Havana; 6 tons into the North West Harbor at Baltimore, and 3-4/10 tons into New York tidal waters, at the present time. Assuming that the population of the Metropolitan District of
39 New York will be 12,000,000 in 1940 (Table No. 2, Page 28), and estimating upon the same per capita contribution of wet sludge as produced in 1910, we find that there will be delivered into New York Harbor in 1940, 6-8/10 tons of wet sludge per million cubic feet of new water available for dilution. It is interesting to note that in 1940, the total dilution and tons of wet sludge per million cubic feet of water available for dilution in New York Harbor, will be approximately equal to the figures for the North West Harbor in Baltimore at the present date, where conditions, as has been previously stated, are obnoxious.

Value of Standards.

The difficulty of finding a simple rule, or fixed standard of purity, for use as a medium for the practical expression of the safe limit of pollution, without danger of passing the critical point, at which a harbor or tidal estuary, as a whole, will assume generally unsatisfactory condition, has been referred to in several paragraphs of this report.

Of the standards suggested in this report, the amount of dilution and the oxygen content of the water have been most generally used. A certain amount of dissolved oxygen is required to convert the organic matter in sewage into gases and mineral salts. This leaves the water for the time, deficient in the quantity of dissolved oxygen present. The amount of this deficiency is a measure of the activity of the processes of decomposition and of the capacity of the water to decompose additional organic matter. In the absence of dissolved oxygen, putrefaction takes place, accompanied by foul odors.
40 As has been stated, putrefaction should not occur, theoretically, as long as any dissolved oxygen remains, but, practically, it has been found that it does occur when an appreciable amount of oxygen is present in the water. Opinions differ widely as to the point below which the dissolved oxygen may be safely reduced. Some claim 70 per cent of saturation is necessary to prevent malodorous conditions, others 50 per cent, and some foreign authorities place the limit even lower.

Standards based on the permissable minimum dilution are necessarily founded upon numerous observations of the chemical con-

stituents found in waters, corresponding to such dilutions, on the assumption of a fair normal composition for water and sewage.

Standards of the permissable minimum dilution, as applied to the general conditions in a harbor, must be based on the assumption that sewage is emptied into a body of water of unvarying volume, flowing with sufficient rapidity to prevent deposits. If instead, the sewage is turned into a body of water where the currents are sluggish, the solid particles of the sewage may accumulate and decompose, giving off offensive gases. Fluctuations in tide, where they cause large areas to be alternately covered with water and left bare, as at Lynn, Mass., and large areas of shallow water are unfavorable for the proper disposal of sewage. Marshes are similarly unfit.

The extent of diffusion and dispersion of sewage must be considered in connection with a standard for the minimum permissable dilution, as the total dilution based upon the total flow in a harbor is never safe, for the reason that sewage emptying into a
41 harbor is never so diffused and dispersed as to include the total flow available for dilution, and then there is the deposition of solid matter at slack tide, causing the accumulation of mud on the harbor bottom and the inability of this mud, as the layers become thicker, to extract oxygen from the water at a sufficient rate to prevent putrefactive action. The form and depth of the sewer outlet, its location, the density of harbor water, as well as its temperature, to some extent its turbidity, and the tidal movement at the outlet must all be considered. Density, dispersion, diffusion, dilution and depth are each important modifying elements.

In short, there are many things which require careful consideration in each case, and many factors which cause a considerable variation from any general rule which may be laid down. The factors affecting standards based on the minimum permissable dilution affect equally as well as standards based on the dissolved oxygen content of harbor waters, or the other standards which have been proposed from time to time, such as the determination of free and albuminoid ammonia, of nitrates, putrescibility tests, and a combination of the tests for nitrates, or the ammonias, and dissolved oxygen.

Many authorities in England claim that no test or standard of any value has as yet been determined, and this view cannot be criticised insofar as there is certainly no general standard which suggests the local and specific nuisance which may occur as a result of emptying sewage into adjacent tidal waters, even though the general conditions are such as not to affect the human senses appreciably.

42 Your Committee have added the "Quantitive Putrescibility Tests on Harbor Muds," as they express more particularly the condition of the deposed suspended organic matter carried by the sewage and which usually cause the putrefactive odors.

It is not impossible to have a large theoretical dilution and a reasonably high oxygen content and yet encounter the putrefactive action of mud on a harbor bottom. When this action occurs, odors and consequent nuisance will be produced in greater or less amounts

depending upon local conditions, and it seems, therefore, that an important factor in the determination of the safe general limits of pollution in a harbor should take into consideration some standard relating to the permissable putrescibility of harbor mud.

It may be said, indeed, in nearly all cases, that at the outlets of outfall sewers, where the deposition of suspended matter is greatest, the olfactory nuisance frequently occasioned, arises more from the putrefaction of the mud than from the presence of sewage in the vicinity.

The last standard suggested in this report of the allowable tons of wet sludge, per million cubic feet of available water for dilution, is more definite than the simple method of expressing dilution as a ratio between the volume of sewage and the volume of water into which it discharges, for the reason that sewage strength varies with its per capita volume and the total amount of organic matter to be digested is really a function of the population served rather than of sewage volume.

Your Committee does not feel that the standards presented
43 are necessarily interpretable within close limits, but that, when considered together, they harmonize sufficiently to convey in a clear general way the critical point at which the general condition of a harbor will become offensive.

Form of Nuisance.

Various terms have been used to express an undesirable condition in a harbor or stream resulting from sewage pollution. It is customary to sum up the whole condition resulting from sewage pollution under the generic term of "Nuisance," and attempts have frequently been made to classify the different kinds of nuisances resulting from the presence of sewage in harbors.

The first classification which naturally suggests it-self is that of general and local, the general nuisance relating more specifically to those conditions which prevail in harbors which have been grossly polluted, and where the area affected by nuisance is co-extensive, or nearly so, with the harbor area, or at least with the area of a large section of the harbor.

Local nuisances refer more particularly to those, resulting in the vicinity of sewer outfalls, or those found in restricted or confined areas.

Nuisances also may be classified as "sensible," of which class there are two sub-divisions, namely, "visual" and "olfactory."

Another form of nuisance may be "injurious," and in this class may be included "infective" nuisances, or nuisances which produce sickness through infection resulting therefrom. Sensible nuisances, while not necessarily infectious, may produce injury to property, as, for instance, through the soiling of beaches, through the
44 injury to paint by the evolution of hydrogen sulphide, through the depreciation of property by the stench developed or by visual filth.

Definition of Nuisance.

It is no less difficult to phrase a definition expressing the condition which constitutes a nuisance than it has been shown to be to establish a simple rule or standard for determining the critical point at which a general nuisance will result.

The following definition, however, is offered as a reasonable one: A state, condition or thing which produces involuntary repugnance through the senses of a normal man, or which causes injury to the property or health of man.

It is not necessary for a nuisance to become general in order for it to conform to this definition, and yet it must be admitted that the definition is a reasonable one, as it applies more specifically to man's comfort than to his esthetic sense. It is uncomfortable for the normal man to live or work in a stench, or to be surrounded by visual filth. It is uncomfortable to be damaged in person or property. The use of a harbor in such a way as to transgress the just restrictions upon such use, which the proximity of other persons or property, in a civilized community, imposes upon what would otherwise be rightful freedom, is a nuisance. It is not necessary for the entire community to suffer discomfort; if only a fractional part does so, then just restrictions are transgressed. The number of people
45 affected has only to do with the extent of the nuisance, its quantitive and not its qualitive aspect.

Local Nuisance.

Long before a harbor has become a general nuisance, as in the case of the North West Harbor at Baltimore, local nuisance occurs as a result of sewage pollution.

An estimate of the extent and degree of the local nuisance resulting from sewage is dependent upon many factors, and it is necessary to deal with conditions as they have been observed to exist in order that such an estimate may be accurate.

Appearance of Sewage.

When an average sample of unscreened or unsettled sewage is placed in a bottle, the sewage has a dirty, gray color; if fresh, a musty and rather unpleasant odor, and if stale, a decidedly disagreeable odor, not unlike that of hydrogen sulphide. It contains the usual sewage filth, toilet paper, broken down feces, grease balls, trash, match sticks, etc. The particles of suspended matter vary materially in size. The small solid particles are usually composed of fecal matter, disintegrated paper, fiber and cloth, and ordinary detritus. When allowed to stand, much of the suspended matter settles down, causing a dirty, gray slimy sludge to accumulate at the bottom. If allowed to stand at summer temperature, the sewage becomes putrid. If greatly diluted, the sewage does not putrify, nor give off offensive odors, the decomposable organic substances being gradually
46 oxidized and converted into harmless and inoffensive compounds. The offensive odors of putrefaction are produced when the natural purifying agencies are overtaxed.

When crude sewage is emptied into a harbor it carries with it all of the suspended matter which is inherent in it, and the suspended matter and detritus in the sewage creates the visual nuisance.

When a sewage is discharged into a harbor where the turbidity is low, a marked discoloration of the water usually occurs and the water contains a large mass of visible particles of the paper, feces, and other solid matter, and the water of the harbor becomes decidedly turbid. The surface which is discolored is frequently sharply separated from the surrounding water, and as the current or tide carries the sewage away from the outfall, this discoloration expands.

As a rule, the sewage keeps its integrity well, but it eventually loses its turbidity by intermixture with the waters into which it is discharged.

The surface of this discolored area is usually covered with a film of grease. This greasy film is persistent and usually lasts longer than the discolored area with which it is first associated. Long after the turbidity has disappeared from the surface, particles of paper and suspended matter, and minute white flakes in large numbers may be observed. The white flakes consist largely of insoluble soap which have been produced by chemical combination between soluble soap and the calcium and magnesium salts, which are present in both salt and fresh water.

47 **Density.**

Sewage when discharged into sea water will rise to the surface, and this rise is due chiefly to the difference in specific gravity between the two liquids.

Turbidity.

Turbid waters act as a mask to shield visual effects. In Washington and Savannah, this was marked and no doubt the visual nuisance in waters with a turbidity of above fifty parts per million will be confined within very restricted limits.

Visual Sewage Field.

When sewage is emptied into a harbor at the surface, it spreads out over the surface water in the vicinity of the outlet, carrying with it the filth, the specific gravity of which is insufficient to cause immediate settlement.

If sewage is discharged horizontally below the surface of a harbor, the inflowing sewage preserves its integrity for a considerable distance, depending upon its initial velocity at the outlet, and rising upwards, spreads out in a layer upon the surface, and carrying with it, as before, the suspended filth which does not readily settle.

If directed upward vertically, the discharged sewage immediately rises to the top in a gradually enlarging column, forming a mushroom shaped cone at the surface, and spreading out thinly at the top upon the water surface.

If deflected downward at the outlet, the sewage spreads to some ex-

tent at the sewer opening, and, reversing its direction of flow,
48 rises upwards about the opening of the sewer and spreads out on the surface.

The rate at which the sewage will rise is a function of the relative density, or salinity, of the harbor water and of the sewage discharged. The greater the salinity of the water, the more rapid the rise. Temperature, also, plays some part in this phenomenon, and the greater the difference in temperature between the sewage and the water, the greater the rate at which the sewage rises to the top. The observations of your Committee, however, lead them to believe that the temperature effects are considerably less by comparison than those caused by differences in salinity.

The tides, or currents, in a harbor, passing the sewer outlet distort to a greater or lesser extent, depending upon the velocity of those tides or currents, the normal curves, or lines, which the rising sewage would follow in still water, and thus change in some small degree the location of the point at which the rising sewage stream intersects the surface of the harbor water. At ordinary depths, however, the deflection of the sewage as a result of tidal, or current velocities, is not sufficient to remove the visual effects produced on the water surface.

Observations of the sewer outfalls at Havana, Tampa, Jacksonville, Savannah, Charleston and Washington prove that the general statements, above made, with relation to the action of sewage thus discharged, are not affected materially by tides or currents. These outfalls included those discharging horizontally at the harbor
49 surface, horizontally below the surface, vertically below the surface, and downward below the surface, those placed below the surface varying in depth from nine to thirty feet below mean tide.

When the sewage reaches the surface it gradually spreads, actuated by the influence of surface currents, winds and tidal phenomena. The shape and form of the visual sewage field is materially affected by local conditions with respect to these elements, and no broad statement can be made. The location of the sewer outlet has a marked effect upon the form of the sewage field. For instance, if the outlet is adjacent to the shore, where the velocity of the current is retarded, the sewage field hugs closely to the shore and parallel to it, following the general direction of the current in mid stream, and forming a long, narrow parallelogram. If the outfall is carried nearer mid stream, the sewage field follows the direction of the current taking the form of a distorted trapezoid or trapezium, with its longest axis parallel to the direction of tidal or current flow, its form depending to a great extent upon the direction and velocity of the wind.

The sewage field is movable with the tides, currents and winds, swings up or down stream as the tide reverses, and spreads out or contracts under the influence of the wind.

As the sewage field spreads, diffusion takes place gradually, until, at some observable limit, varying in distance on divergent radii, from the outlet as a center, the visual field disappears. At this point

the visual nuisance ceases, but deposition of the suspended
50 matter may continue for great distances and under proper conditions this deposition may produce olfactory nuisance. Infective nuisance may continue beyond the limits of the olfactory nuisance produced by the putrefactive action of the bottom mud formed by the deposition of solids.

Diffusion and Dispersion.

The suspended matter contained in the sewage is carried from point to point by the tidal currents and by the action of the wind. Some of the solids may be carried several miles without losing their characteristics. The mixture, however, between sewage and harbor water goes on progressively, taking place from the outside edge of the discolored area. The greatest diffusion proceeds apparently from the bottom of the sewage mass.

The transporting power of water for suspended sewage solids varies as the square of the velocity of the moving current. Therefore, if the velocity is reduced by one-half, the capacity of the water to carry solid particles in suspension will be reduced to one-quarter. The effect of the velocity of current on transporting power is a very important element in the dispersion of sewage matter, for when harbor water becomes slack by reason of the change of tide, deposition goes on rapidly beneath the sewage field, piling up the sewage sludge on the bottom, there to lie and putrefy, and as the odors caused by the putrefaction of deposits upon the bottom are the most intense and offensive of any odors produced by the discharge of sewage into a harbor, the manner of dispersion and diffusion of the sewage plays an important part in the local nuisances produced.

51 Another factor in the dispersion of sewage, and one which should not be overlooked, is that the relative rate of deposition of solid matter in sea water is much greater than in fresh water. Water which is strongly saline will not transport as much solid matter in suspension as will water without salt. The capacity of a harbor, therefore, for carrying sewage matter to sea cannot be safely estimated from the information obtained merely from a study of inland rivers.

It may be said, in general, that deposits of sewage sludge exist not only in the immediate neighborhood of sewage outfalls, but to a degree, for considerable distances from these outfalls.

Local sewage discharge, therefore, may cause grave sensible nuisance, extending over large areas and in considering the problem of harbor pollution these local nuisances must be of prime consideration, even though a larger area of harbor may be unaffected by them. Standards for dilution, for the permissible per cent of oxygen saturation, or other standards, based on general averages, are no guide to the local nuisance which may result. A study of local physical conditions at sewage outfalls, as they exist, is essential to a conclusion.

51a

Chemical Studies.

In addition to the field determinations of dissolved oxygen, salinity, turbidity and the putrescibility of muds, special experiments were conducted by Mr. Leon R. Whitcomb, chemist in the laboratory of one of your Committee, Mr. Nicholas S. Hill, Jr., with relation to the comparative results obtained by the Winkler and Levy methods for the determination of dissolved oxygen, and also for the purpose of determining the effect of nitrites in the accuracy of the Winkler method.

The laboratory methods and apparatus used, together with detailed description of the work outlined above, is given in Appendix IV.

The results which are shown in the Tables Appendix IV have been corroborated by independent investigations conducted by Dr. Jackson at the Mount Prospect Laboratory.

51b

Summary and Conclusions.

1. A general nuisance will, under ordinary conditions, result in a harbor into which sewage is emptied:

a. When the dilution approaches 1-26.

b. When the per cent of saturation with dissolved oxygen falls to 23.5.

c. When the number of tons of wet sludge per million cubic feet of total new water, available for dilution, amounts to 6.

2. A general nuisance may occur in a harbor into which sewage is emptied:

a. When the ratio of dilution falls at some point between 1-60 and 1-30.

b. When the per cent of saturation with dissolved oxygen falls at some point between 65 and 23.5.

c. When the number of tons of wet sludge per million cubic feet of total new water, available for dilution, amounts to between 3.5 and 6.

3. A general nuisance will not occur in a harbor into which sewage is emptied under ordinary conditions:

a. When the ratio of dilution exceeds 1-60.

b. When the per cent of saturation with dissolved oxygen exceeds 65.

c. When the number of tons of wet sludge per million cubic feet of total new water, available for dilution, is less than 3.5.

4. No standards or rules relating to general conditions give a basis upon which an estimate can be made of the extent to which local nuisances may occur.

5. Serious local nuisances, sensible, injurious and infectious, frequently occur where there is no general nuisance.

51c 6. The present pollution of New York Harbor is approaching the critical point at which a general nuisance may occur.

7. If the crude sewage from the Metropolitan Sewerage District, or a large part of it, continues to be discharged into the tidal waters

in the vicinity of New York, up to 1940, serious general nuisance will probably result at, or before, that time.

8. Serious local nuisances now exist in New York Harbor.

9. It seems from comparative experiments conducted with the Levy and Winkler methods for the determination of dissolved oxygen, that the true percentage of dissolved oxygen presented in this report, and as stated for New York Harbor by the Metropolitan Sewerage Commission and the Central Committee Experts, is, if anything, rather higher than the true percentages which actually obtain.

10. To discharge crude sewage from the Passaic Valley Sewerage District, in the amounts proposed, and at the point selected at Robbins Reef, would create another local nuisance of wide extent and materially hasten the approach to the critical point at which a general nuisance will exist in Upper New York Bay.

Respectfully submitted,

DANIEL D. JACKSON.
THEODORE HORTON.
NICHOLAS S. HILL, Jr.

March 15, 1912.

52 APPENDIX I.

Giving Basic Data and Explanation of the Method of Obtaining Land-water Drainage Areas Tributary to the Harbors Considered, the Annual Rainfall in These Drainage Areas, the Volume of Land Water Flow, the Tidal Ranges and Tidal Areas of the Harbors Considered, and the Normal Characteristics of the Harbor Waters (Table No. 1, Page 28).

A. The Tributary Land Water Drainage Area, Col. 2, in the case of each harbor, has been carefully computed from the best obtainable maps.

For Havana, no reliable map was obtainable, and the statement of Mr. H. E. Hyde of the Obras Publicas, Havana, has been accepted.

For New York, the area is given as stated on Page 14 of the Central Committee's "Basic Physical Data Relating to the Metropolitan and Passaic Valley Sewerage Districts.

For Baltimore and Boston, it was computed from the topographical maps of the United States Geological Survey.

For Washington, the drainage area of the Potomac River is taken as stated in a paper on "Hydrography of the Potomac Basin," Trans. Am. Soc. C. E., Vol. XXVII, Page 21 et seq.

For Savannah, the drainage area of the Savannah River above Augusta was obtained from Water Supply and Irrigation Paper No. 204. Below Augusta, and above Savannah, it was computed from a State map of Georgia, published by the Georgia State Geo-
53 logical Survey, and the total area thus derived was checked with local estimates.

For Tampa, Jacksonville and Charleston, it has been taken from the United States Post Route maps.

(Table A- "178)

-RAINFALL AND RUNOFF.-

-VARIOUS STREAMS ALONG SOUTH ATLANTIC COAST.-

	Month.	-Maximum Year.-1901.- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall	-Average Year.-1898-1908- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall	-Minimum Year.-1904- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall
Broad River, Ga., near Carlton, Ga. Drainage Area - 762 Sq. Mi.	Jan.	3.40	3.17	93.2	4.14	2.30	55.6	3.10	1.12	36.2
	Feb.	3.47	2.32	67.0	6.02	3.32	55.1	4.23	1.58	37.2
	Mar.	6.21	3.42	55.1	5.72	3.47	60.6	4.04	1.89	46.8
	Apr.	6.84	3.55	51.9	4.24	2.27	53.6	2.09	1.05	50.3
	May	3.97	2.54	42.6	3.27	1.62	49.5	2.58	0.93	36.8
	June	6.04	3.44	57.0	4.74	1.83	38.6	3.40	0.70	20.6
	July	4.28	1.93	45.4	5.26	1.79	34.0	3.29	0.79	24.0
	Aug.	13.64	9.83	30.9	6.71	2.44	36.3	7.06	2.13	30.2
	Sept.	5.55	3.14	56.6	4.21	1.71	40.6	0.94	0.69	73.4
	Oct.	1.12	1.64	146.4	3.05	1.33	43.6	0.24	0.47	195.8
	Nov.	0.62	1.32	212.9	2.96	1.21	40.9	2.81	0.64	22.8
	Dec.	6.83	4.18	61.2	5.18	2.18	42.1	4.08	1.04	25.5
	TOTALS	67.94	35.48	52.2	55.50	25.47	45.9	37.88	13.05	34.5
	Month.	-Maximum Year.-1908.- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall	-Average Year.-1899-1908- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall	-Minimum Year.-1904- Rainfall. (inches in depth)	Runoff. (inches in depth)	% of Runoff to Rainfall
Savannah River, at Augusta, Ga., Drainage Area 7294 Sq. Mi. [1899-1908] at Woodlawn, S.C., Drainage Area 6600 Sq. Mi.- [1907 & 1908]	Jan.	3.42	3.44	63.4	4.08	2.16	52.9	2.96	0.88	29.7
	Feb.	6.22	4.20	67.6	6.17	3.24	52.5	4.34	1.36	31.4
	Mar.	4.78	3.02	63.2	5.24	3.10	59.3	3.84	1.36	35.4
	Apr.	6.57	3.22	49.1	3.97	2.08	52.4	1.94	0.84	43.3
	May	2.15	1.72	80.0	3.34	1.45	43.4	2.68	0.68	25.4
	June	4.80	2.16	45.0	5.20	1.86	35.8	3.47	0.62	17.9
	July	3.49	1.80	52.8	4.83	1.45	30.0	3.81	0.60	15.8
	Aug.	11.83	4.39	36.8	6.60	1.94	29.4	7.82	1.86	23.8
	Sept.	2.29	1.76	76.9	3.86	1.39	36.0	1.07	0.58	54.1
	Oct.	4.76	1.56	32.8	2.65	1.12	42.3	0.27	0.33	122.2
	Nov.	1.80	1.67	92.8	2.61	1.04	39.9	2.71	0.46	17.0
	Dec.	4.83	2.48	51.4	5.30	1.94	36.6	4.04	0.75	18.6
	TOTALS	60.64	31.62	52.2	53.85	22.79	42.2	38.95	10.33	26.5

Table B-1781

-RAINFALL AND RUNOFF.-

-VARIOUS STREAMS ALONG SOUTH ATLANTIC COAST.-

	Month.	Maximum Year.-1900.- Rainfall Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall.	Average Year.-1893-1908. Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall.	Minimum Year.-1904 Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall.
Ocmulgee River at Macon, Ga.	Jan.	2.09	0.73	34.9	3.76	1.46	38.8	3.12	0.98	31.4
	Feb.	9.23	4.16	45.1	5.40	2.48	45.9	3.83	1.40	36.6
	Mar.	4.16	2.21	53.1	4.75	2.56	53.9	2.22	1.05	47.5
	Apr.	5.82	3.22	55.3	3.91	1.84	47.1	1.60	0.71	44.4
	May	2.45	1.36	56.6	2.94	0.98	33.3	2.20	0.53	24.1
Drainage Area = 2425 Sq Mi.	June	7.83	3.78	48.3	3.68	1.18	32.1	2.24	0.47	21.0
	July	4.03	1.72	42.7	4.73	1.18	25.0	3.37	0.37	11.0
	Aug.	4.29	0.95	22.1	5.24	1.25	23.8	8.03	1.41	17.6
	Sept.	2.98	1.18	39.6	2.82	0.97	34.4	0.58	0.31	53.5
	Oct.	1.99	0.89	44.7	2.62	0.86	32.8	0.29	0.14	48.2
	Nov.	3.95	1.06	26.8	2.66	0.79	29.7	2.98	0.28	9.4
	Dec.	6.44	1.94	30.2	4.35	1.36	31.2	4.70	0.62	15.1
	Totals	55.26	23.20	42.0	46.87	16.91	36.1	34.56	8.26	23.9
	Month.	Maximum Year.-1901.- Rainfall. Inches in Depth	Runoff.- Inches in Depth	% of Runoff to Rainfall.	Average Year.-1893-1906. Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall.	Minimum Year.-1904.- Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall
Oconee River at Dublin, Ga.	Jan.	3.87	2.60	67.1	3.37	1.82	54.0	2.87	1.07	37.3
	Feb.	4.02	2.32	58.6	6.11	2.74	44.8	4.15	1.70	41.0
	Mar.	5.58	1.79	32.1	5.01	2.68	53.5	2.39	1.30	54.6
	Apr.	3.99	3.28	82.1	2.79	2.03	72.7	1.21	0.74	61.1
	May	4.12	1.18	28.6	3.05	1.03	33.8	2.23	0.52	23.3
	June	6.48	2.15	33.2	4.88	1.28	26.4	2.06	0.39	18.9
Drainage Area = 4182 Sq. Mi.	July	4.37	1.18	27.0	4.52	1.02	22.6	2.44	0.32	13.1
	Aug.	7.57	1.65	21.8	5.16	0.99	19.2	6.07	1.00	15.0
	Sept.	4.73	2.14	45.3	2.75	0.81	29.5	0.95	0.30	31.6
	Oct.	0.90	0.84	93.3	2.55	0.66	25.9	0.52	0.17	32.6
	Nov.	1.07	0.62	58.0	2.29	0.58	25.3	2.95	0.32	10.8
	Dec.	4.73	1.22	25.8	4.58	1.20	26.2	4.06	0.64	15.8
	Totals	51.43	20.98	40.8	47.06	16.84	35.8	32.49	8.47	26.1

(Table C 5/78)

- RAINFALL AND RUNOFF. -

- VARIOUS STREAMS ALONG SOUTH ATLANTIC COAST. -

	Month.	Maximum Year. -1903 - Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall.	Average Year. -1902-1907. Rainfall. Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall	Minimum Year. -1904 - Rainfall Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall
Broad River, S.C., near Alston, S.C.	Jan.	3.26	2.47	70.7	2.88	2.31	80.2	2.92	0.98	33.5
	Feb.	8.04	5.11	63.5	4.79	2.94	61.4	3.66	1.69	46.2
	Mar.	7.06	6.40	90.7	3.72	3.13	84.2	2.91	1.78	61.1
	Apr.	3.35	3.77	112.5	2.88	1.85	64.2	1.48	1.08	73.0
Drainage Area - 4,609 Sq. Mi.	May	2.30	1.61	70.0	3.53	1.40	39.6	2.11	0.92	43.6
	June	8.90	5.04	56.6	4.96	2.10	42.3	2.47	0.95	38.4
	July	2.78	1.11	40.0	4.69	1.42	30.3	6.19	1.04	16.8
	Aug.	5.03	1.71	34.0	6.24	2.15	34.4	6.55	3.06	46.7
	Sept.	3.70	1.07	29.0	3.37	1.18	35.0	1.19	0.67	56.3
	Oct.	2.92	0.78	26.7	2.65	0.95	35.8	0.88	0.40	45.4
	Nov.	1.33	0.88	66.1	4.33	1.01	23.3	3.11	0.73	23.4
	Dec.	1.62	0.90	55.5	4.24	2.20	51.9	3.41	1.22	35.8
	TOTALS.	50.29	30.85	61.4	46.28	22.64	49.0	36.88	14.55	39.6
	Month	Maximum Year. - 1899. - Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Average Year. - 1899-1903. - Rainfall Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Minimum Year. - 1898. - Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to rainfall
Cape Fear River, at Fayetteville, N.C.	Jan.	6.71	4.46	66.2	3.71	1.81	48.8	1.94	0.54	27.8
	Feb.	4.24	4.00	94.5	4.29	2.53	59.0	0.95	0.41	43.2
	Mar.	2.33	1.39	59.5	3.89	2.13	54.7	4.41	0.85	19.3
	Apr.	2.76	1.34	48.6	3.37	1.63	48.4	3.36	1.09	32.5
	May	4.77	0.51	10.7	4.77	1.05	22.0	3.73	0.61	16.4
Drainage Area = 4,493 Sq. Mi.	June	5.03	1.76	34.9	4.19	0.91	19.3	3.12	0.29	9.3
	July	14.04	5.33	37.9	6.11	1.27	20.8	4.72	0.71	15.1
	Aug.	6.96	4.07	58.4	5.69	1.47	25.8	8.05	1.45	18.0
	Sept	3.68	0.85	23.1	3.80	0.79	20.8	3.39	0.91	26.8
	Oct.	3.32	0.86	25.9	3.28	0.73	22.2	3.78	0.45	11.9
	Nov.	3.23	1.94	60.0	2.65	0.65	24.5	3.23	0.73	22.6
	Dec.	0.64	0.63	98.4	2.90	0.89	30.7	2.23	0.86	38.6
	TOTALS	57.71	27.41	42.6	48.65	15.76	32.4	42.91	8.90	20.7

Card No. 1-24

-RAINFALL AND RUNOFF.-

VARIOUS STREAMS ALONG SOUTH ATLANTIC COAST.-

	Month	Maximum Year.-1901.-			Average Year.-1897-1904.			Minimum Year.-1904.		
		Rainfall Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall	Rainfall Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall	Rainfall Inches in Depth	Runoff Inches in Depth	% of Runoff to Rainfall
Roanoke River at Roanoke, Va.	Jan.	2.36	1.49	63.2	2.80	1.51	54.0	2.09	0.45	21.6
	Feb.	0.71	0.66	93.0	3.91	2.54	66.7	1.90	0.64	33.6
	Mar.	3.26	1.58	48.5	4.23	3.01	72.8	2.44	1.18	49.4
	Apr.	6.30	4.90	75.4	2.92	1.98	67.8	2.23	0.56	25.4
	May	7.46	4.36	58.4	3.79	1.72	45.4	3.44	0.87	25.2
Drainage Area 388 Sq. Mi.	June	7.06	2.54	35.9	5.04	1.17	23.2	8.14	1.19	14.6
	July	5.26	2.55	48.4	4.08	0.86	21.0	5.10	0.78	15.3
	Aug.	10.72	5.72	53.3	3.78	1.35	35.7	3.31	1.35	40.7
	Sept.	3.52	1.30	37.0	3.33	0.73	21.9	1.22	0.38	31.2
	Oct.	0.86	0.79	91.9	2.94	0.91	30.9	0.15	0.27	207.8
	Nov.	1.04	0.53	51.0	2.24	0.72	32.2	1.87	0.32	17.1
	Dec.	7.45	4.23	56.7	3.23	1.40	43.3	3.16	0.35	11.1
	TOTALS	56.20	30.65	54.5	42.19	17.90	42.4	35.07	8.36	23.8

(Table E - #1781

- RAINFALL AND RUNOFF. -

- VARIOUS STREAMS ALONG NORTH ATLANTIC COAST. -

	Month.	Maximum Year - 1901.			Average Year - 1868-1908			Minimum Year - 1880.		
		Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall
Croton River, N.Y.	Jan.	1.63	1.15	70.5	4.10	2.65	64.6	3.43	2.38	69.4
	Feb.	0.84	0.54	64.3	4.05	3.13	77.2	3.40	2.92	85.8
Drainage Area = 338.8 Sq. Mi.	Mar.	7.18	5.10	71.0	4.23	4.24	100.2	3.90	2.74	70.2
	Apr.	8.19	7.63	93.2	3.38	3.25	96.2	3.57	1.99	55.8
	May	7.01	4.29	61.2	3.89	1.98	50.9	1.04	0.88	84.6
	June	1.48	1.72	116.2	3.59	1.18	33.8	1.40	0.35	25.0
Note:- Runoff Figures reduced to Zero Evaporation from Reservoir surfaces.	July	8.35	1.46	17.5	4.74	0.71	15.0	5.86	0.29	4.9
	Aug.	9.03	3.74	41.4	4.96	1.06	21.4	4.16	0.17	4.1
	Sept	5.49	2.24	40.8	4.23	1.05	24.8	2.42	0.25	10.3
	Oct.	3.94	2.58	65.5	4.05	1.18	29.1	2.83	0.17	6.0
	Nov.	1.80	1.21	67.2	3.80	1.65	43.4	2.32	0.47	20.6
	Dec.	8.81	4.40	49.9	3.93	2.09	53.2	2.59	0.33	12.7
	TOTALS	63.75	36.06	56.6	48.95	24.17	49.4	36.92	12.94	35.1

	Month.	Maximum Year - 1888.			Average Year - 1875-1908.			Minimum Year - 1883.		
		Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall	Rainfall. Inches in Depth	Runoff. Inches in Depth	% of Runoff to Rainfall.
Sudbury River, Mass	Jan.	4.13	1.84	44.3	4.14	2.18	52.7	2.81	0.58	20.6
	Feb.	3.68	3.41	92.6	4.18	3.05	73.0	3.87	1.81	46.8
Drainage Area = 75.2 Sq. Mi.	Mar.	6.02	5.66	94.0	4.50	5.06	112.5	1.78	2.82	158.4
	Apr.	2.43	4.63	190.5	3.50	3.59	102.6	1.84	2.36	128.2
	May	4.82	2.86	59.4	3.42	1.93	56.5	4.19	1.64	39.1
	June	2.54	0.73	28.7	3.11	0.91	29.2	2.40	0.52	21.6
	July	1.41	0.20	14.2	3.66	0.33	9.0	2.68	0.20	7.5
	Aug	6.22	0.66	10.6	3.91	0.46	11.7	0.73	0.14	19.2
	Sept.	8.59	2.02	23.6	3.51	0.46	13.1	1.52	0.16	10.5
	Oct.	4.99	3.50	70.0	4.07	0.85	20.8	5.60	0.32	5.7
	Nov.	7.22	4.82	66.8	3.84	1.49	38.8	1.81	0.36	19.9
	Dec.	5.40	5.32	98.4	3.84	1.86	48.5	3.55	0.34	9.6
	TOTALS	57.47	35.65	62.1	45.68	22.17	48.5	32.78	11.25	34.3

B. The Mean Annual Rainfall, Col. 3.

For Havana, was estimated from data relating to the State of Florida, obtained from the United States Weather Bureau.

For Baltimore, the value used is that given by the records of the Baltimore City Water Department.

For Washington, the mean annual rainfall for the Potomac Basin was obtained from the paper on Rainfall and Stream Flow by John C. Hoyt, Trans. Am. Soc. C. E.; Vol. LIX, Page 455.

For Savannah, the figures given in the Table, Page 54, of the rainfall in the Savannah River Basin were used. The rainfall figures used in this table, as well as in the tables for the Ocmulgee, Oconee, Broad, Cape Fear and Roanoke Rivers were obtained from published reports of the United States Weather Bureau and were carefully compiled.

For Tampa, Jacksonville and Charleston, values have been obtained from a careful study of the data on rainfall in the basins of comparable southern rivers shown in the tables, Pages 54 to 57.

For Boston, the figures for the Sudbury River shown in the Table, Page 58, are used, these figures having been carefully compiled from the records of the "Boston Metropolitan Water and Sewerage Board," published in their reports.

(Here follow tables marked A, B, C, D, and E, pages 54, 55, 56, 57 and 58.)

59 C. The Fresh Water Flow, Col. 5, or Total Available Run-off.

At Havana, was estimated from the best data available, and taken at one (1) second foot per square mile.

At Baltimore, in estimating the total run-off available from the basin of Jones Falls, an area sufficient to supply the quantity of water taken from the stream, for water supply purposes, has been deducted from the total area of the basin, and the resulting quantity of run off has been checked against the records of the Baltimore City Water Department of the flow of Jones Falls, from which the City obtains a portion of its water supply.

At Washington, the volume of run off has been computed from the data presented in the paper on "Hydrology of the Potomac Basin, Trans. Am. Soc. C. E. Vol. XXVII, Page 21 et seq., and checked against gaugings of the Potomac River reported by the Superintendent of Sewers, Washington, D. C., in his report for the year 1910.

At Tampa, Charleston and Jacksonville, the run-off has been estimated by assuming 40 per cent of the rainfall as available run-off, 40 per cent being estimated from a careful study of the comparable southern rivers, data for which *is* shown in the tables, Pages 54-57.

At Savannah, the runoff was computed from the data shown in the Table, Page 54, which has been carefully compiled from gaugings of the Savannah River reported in the publications of the United States Geological Survey.

60 At Boston, the run-off was computed from data for the Sudbury River shown in the table, Page 58, which has been carefully compiled from the published records of gaugings made by the Boston Metropolitan Water and Sewerage Board.

D. The Tidal Range, Col. 6.

In Upper New York Bay was obtained from the "Report of the New York Metropolitan Sewerage Commission, 1910," Page 156.

For Boston, from the statement of the Boston Metropolitan Water and Sewerage Board.

For Charleston, from the office of the Charleston City Engineer, and

For the other harbors from local sources, and checked against the tidal range given on the United States Coast and Geodetic Survey Charts of the harbors in question.

E. The Tidal Area Considered, Col. 7.

For New York is the area of Upper New York Bay as stated on Page 156 of the "Report of the Metropolitan Sewerage Commission of New York, 1910."

For Boston, the tidal area is used as stated on Page 147 of Appendix XIX of the "Report on Sewage Disposal of Paterson, N. J." by Allen Hazen.

For the other harbors the tidal area has been computed from the harbor charts of the United States Coast and Geodetic Survey.

F. The Physical and Chemical Characteristics of the Harbor Waters, Cols. 8, 9, 10 and 11, have been taken from the Tables Pages

(Continued from "178)

EXAMINATION OF HAVANA HARBOR WATER.

NO.	TIME	TEMP.	TURB.	CHLORINE	DISS. OXYGEN Pts per M	DISS. OXYGEN % Sat.	REMARKS
1	6th Test 11.00 AM	75	20		0	0	Off East of San Jose or
2	11.20 AM	75	22	15600	0	0	Op Arsenal East End
3	11.35 AM	75	45	12500	0	0	E End Tallapiedra Wharf near Sewer
4	12.00 AM	75	75	4200	0	0	Off San Nicholas Creek
5	12.20 PM	75	200	100	0	0	In San Nicholas Creek
6	12.50 PM	76	186	75	0	0	Matanzas Creek at Channel Buoy
7 a	2.30 PM	75	60	7500			Upper Harbor 200 E of Matanzas Creek
b	2.20 PM	75	45	12250			Upper Harbor 400 E of Matanzas Creek
c	2.10 PM	75	40	14500			300 N.E of last point
d	1.40 PM	75	40	14500			250 N.E of last point
e	1.20 PM	75	20	15200			250 N.E of last point
f	3.00 PM	75	18	10500	6.67	94.9%	Near Steamship Moore
g	9/12			20300			Gulf stream 20 miles N of Havana
h	10/12	65		19200			Off Punta Gorda, West Coast of Fla
i	11/12	65		19200			Off Tampa, Fla

Test Ess
Tissot Horse - 1 foot

(Exhibit No. "178")

EXAMINATION OF BALTIMORE HARBOR WATER
BY
O. O. JACKSON

SAMPLE	TIME	TEMP	TURB	COLIGENE	DIS. OXYGEN Pts. per M.	DIS. OXYGEN % Sat.	REMARKS
1	Dec 2 1914 1.20 PM	46	35	4600	2.25 -	19.8%	End of City Pier
2	1.40 PM	46	30	4600	1.37 -	12.1%	Opp. Pier "J"
3	2.40 PM	48	200	2400	5.30 -	49.0%	100' in Jones Falls Slip
4	3.30 PM	46	150	3000	2.33 -	20.3%	5.00 Below Jones Falls Slip
5	4.00 PM	44	30	9850	4.18 -	35.9%	Off Falls Point
6	Dec 3 1914 11.00 AM	40.5	18	4350	9.65 -	77.5%	Off Locust Point
7	12.30 PM	41	20	4300	10.29 -	84.4%	250' South of R.R. Ferry

High water - 5.40 PM
Wind N.W. about 15 miles per hour
Tide Range 1ft
City 4 miles from Bay and 180 miles from Ocean

EXAMINATION OF BALTIMORE HARBOR WATER.
BY BALTIMORE SEWERAGE COMMISSION 1908, P 55
TIME - NOON TO 2.30 MAY 8, 1908.

NO	LOCATION	WIND	BACTERIA	Dr. Dr. Results Parts per 100 c.c.
1	Foot of Calvert St.	No wind	124,000	2.41
2	Mouth of Jones Falls		73,000	4.53
12	North End Middle Branch		11,500	3.18
6	Ferry Point	Windy	38,000	8.84
4	Off Locust Point.	Windy	113,000	7.39
13	Mouth of Bear Creek	Windy	39,000	11.11
10	Mouth of Patapsco River.	High Wind	3,950	11.79
15	Back River Electric RR Bridge		950	13.90
16	Back River Todd Point.		750	11.02

EXAMINATION OF WASHINGTON HARBOR WATER

NO	TIME	TEMP	TURB	CHLORINE	DISSOLVED OXYGEN		REMARKS
					mg per ml	% Sat	
1	4:00 PM	46	140	25	7.96	68.7%	Over Outfall
2	4:30 PM	45	90	10	9.69	77.8%	300' North of Outfall
3	4:25 PM	43	85	7.5	10.53	83.5%	1000' North of Outfall
4	4:45 PM	42	75	6.5	10.81	84.1%	875' North of Outfall
5	5:00 PM	42	75	6.0	10.81	84.1%	1000 North of Outfall

(P.T. - 1.8)

EXAMINATION OF TAMPA HARBOR WATER

NO.	TIME	TEMP.	TURB.	CHLORINE	DIS. OXYGEN Mg per Ml	DIS. OXYGEN % Sat	REMARKS
1	Thu Nov 4.30 PM	65	90	14400	5.07	69.8%	Op. Seaboard Dock. 20 Feet Down Outfall
2	5.00 PM	63	37	13900	4.42	62.7%	300 Feet Down Outfall & west of entrance
3	5.30 PM	60		3100	6.08	65.5%	50' from Upper Outfall

(Exhibit 7 - cont'd)

(Exhibit J - 4/15)

EXAMINATION OF SAVANNAH HARBOR WATER

NO.	TIME	TEMP	TURB	CHLORIDE	DIS OXYGEN		REMARKS
					P.p.m.M	% Sat.	
1	2:30 PM	45	90	240	9.41	77.9%	East of Broad St
2	3:30 PM	46	150	360	9.65	81.2%	Just above Jetties
3	4:00 PM	46	140	450	9.41	79.5%	Head of Canal
4	4:45 PM	45	120	240	9.41	77.4%	Middle of River
1	8:00 AM	55	55	220	7.80	73.4%	Bilbo Canal
2	8:15 AM	53	75	80	9.81	90.1%	25' West of Bilbo Canal
3	8:30 AM	50	55	70	9.65	85.2%	50 West of Bilbo Canal
4	8:35 AM	50	53	60	9.81	86.7%	100 West of Bilbo Canal
5	8:40 AM	50	40	55	9.73	86.0%	Middle of River
6	8:50 AM	50	53	60	9.00	79.5%	250' Below and E of Bilbo Canal
7	9:05 AM	51	55	60			750' Below and E of Bilbo Canal
8	8:40 AM	50	50	60	9.33	82.4%	1000' below and E of Bilbo Canal
9	9:45 AM	50	60	60	9.09	80.3%	1000' below Bilbo Canal
10	9:50 AM	50	55	80			Middle of River
11	10:25 AM	50-53	50-80	65	9.17	82.5%	Over Outfall

EXAMINATION OF JACKSONVILLE HARBOR WATER

NO.	TIME	TEMP.	TURB.	CHLORINE	DIS. OXYGEN		REMARKS
					Pts per M	% of Sat.	
1	2:45 PM	55	40	3400	8.04	78.2%	30' N of Outfall at foot of Main St
2	2:45 PM	54	55	3200-	6.67	64.1%	Over Outfall
3	3:00 PM	55	40	3400	8.04	78.2%	100' South of Outfall
4	3:15 PM	54	18	3800	9.17	88.4%	1000' N of Outfall and 600' from shore
5	3:30 PM	54	26	3500			1000' W of Outfall and 400' from shore
6	3:45 PM	54	30	3300			1000' W of Outfall and 200' from shore
7	4:00 PM	54	19	4200	9.17		100' SW from Fairfield Outfall and 900' from shore
8	4:25 PM	55	40	3300			Cottage near St. Sewer

River Reclen - 1000' x 40' and velocity 3 miles per hour

Horizontal Discharge in 20 feet of water.
Starts up and spreads out on surface
The 18" Cotteries D. Sewer discharges horizontally in 30' of water.
The 8" Fairfield St. Sewer discharges horizontally in 7' of water and there she boil up and spread out on surface

(Ex. Rule K- 2 1/2)

EXAMINATION OF CHARLESTON HARBOR WATER.

NO.	TIME	TEMP.	TURB.	CHLORINE	DIS OXYGEN		REMARKS
					Pts per M.	% Sat	
1	Mar 11:55 AM	54	18	17600	8.04	90.8 %	Middle Cooper River Op Calhoun St
2 a	12:50 PM	68	80	4450	0	0	Op Old Calhoun St Sewer near Outlet
b	1:00 PM	63	70	6700	1.53	16.9 %	100' from Calhoun St Outlet
3	1:05 PM	55	18	17700			400' off Sc Battery in Ashley River Meeting St Drawn not running
4	1:30 PM	55	28	16600			250' off Barton Creek Ashley River

(Exhibit L — 1981)

-89-

QUANTITATIVE PUTRESCIBILITY TESTS ON MUD.

NO	DATE	HARBOR LOCATION	TEMP	MOISTURE	LOSS ON IGNITION (ash)	PUTRESCIBILITY * (Test)				REMARKS
						1 DAY	2 DAYS	3 DAYS	4 DAYS	
1	3/12 1911	Outboard of Spring Path in 30' of water	48°F	55.3%	11.8%	1-220	1-450	1-670	1-830	Black Putrid Odor
2	3/12 1911	Buildings in Spring Point Creek in 20' of water	48°F	54.4%	15.9%	1-220	1-810	1-955	1-1650	Black Putrid Odor
3	4/12 1911	Virginia Harbor, [illegible]	74°F	54.6%	29.3%	1-1100	1-1300	1-2200	1-2200	Black Putrid Odor
5	4/12 1911	Somerset Harbor	50°F	38.4%	12.1%	1-1	1-5	1-13	1-13	Clay Mud, Faint Odor
6	5/8 1908	Massachusetts Point Mud	73°F	45.5%	23.4%	1-0	1-2	1-2	1-7	Slight Musty Odor
7	5/8 1908	East Weehawken Bottom Mud	76°F	38.0%	32.4%	1-0	1-1	1-2	1-2	Earthy Odor
8	1/8 1908	Mt Prospect Reservoir	75°F	51.0%	20.8%	1-1	1-4	1-6	1-6	Earthy Odor
		NEW YORK HARBOR								
9	2/8 1912	600 N of Govt Landing between Govt Land Elliss I	32°F	53.4%	10.8%	——	1-560	——	1-850	Black Putrid Odor
10	2/8 1912	600' S.W. of Buoy No. 16 in 18' of water	32°F	35.1%	4.3%	——	1-160	——	1-310	" "
11	2/8 1912	Bottom of Buoy #3 in 16' of water	32°F	44.4%	5.9%	——	1-180	1-540	1-720	" "
12	2/8 1912	1000' NE by E of Robbins Reef light in 15' of water	32°F	36.5%	4.4%	——	1-160	——	1-400	" "
13	2/8 1912	1000 from Robbins Reef light on Elizabeth Lake in 15' of water	32°F	52.8%	8.6%	——	1-630	——	1-740	" "
14	2/8 1912	600 from Liberty Island with Bedloes in 16' of water	32°F	57.6%	8.8%	——	1-710	1-940	1-1290	" "

* Solutions made with aerated distilled water, containing 9 parts per million of Oxygen

(Ref. - W. A. Jones)

62-69, which show the results of analysis of samples of the
61 harbor waters made by D. D. Jackson and collected by your Committee, care having been taken in this case to select results which represent the normal harbor water, or water from those parts least affected by sewage pollution.

At New York, the chemical data were obtained from the report of the Metropolitan Sewerage Commission 1910, except the putrescibility tests on mud, which were made in the laboratory of Mr. Nicholas S. Hill, Jr., upon samples collected from New York Harbor on February 8, 1912, and February 13, 1912.

(Here follow tables marked F, G, H, I, J, K, L, and M, pages 62, 63, 64, 65, 66, 67, 68, and 69.)

70 APPENDIX II.

Giving Basic Data and Explanation of the Method of Determining Total Population, Tributary Population, Domestic Sewage Flow, Manufacturing Wastes, Ground Water Infiltration, and Total Sewage Flow.

Table No. 2, Facing Page 29.

A. The Population Figures, Col. 2, have been obtained as follows:
For Havana, from the statement of Mr. H. E. Hyde of the Obras Publicas, Havana.
For Baltimore, from the United States Census of 1910.
For New York, from figures given on Page 13 of "Basic Physical Data Relating to the Metropolitan and Passaic Valley Sewerage Districts," as follows:

	1910.	1940.
Total Population in Metropolitan District..	6,424,530	12,846,560
From this total is to be subtracted:		
1st. The population tributary to Long Island Sound	33,648	81,000
2nd. The population tributary to Lower New York Bay	345,403	966,000
3rd. 16 per cent of the population tributary to the Passaic, Hackensack and Newark Bay—this proportion of the sewage in Newark Bay has been estimated by the Central Committee as flowing into the Lower Bay, through the Arthur Kill, 16%	31,300	78,438
Total Deductions	410,351	1,125,438
	6,014,179	11,721,122

71 The following Table No. 4 shows that the estimate of a population of 12 million within the Metropolitan District in 1940 is very conservative.

TABLE NO. 4.

Comparison of Population Estimated, City of New York.

	1900.	1910.	1940.
*John R. Freeman.....	3,437,202	4,766,883	7,652,000
*Metropolitan Sewerage Commission	.....	.....	8,666,100
Central Committee of Experts State of N. Y.....	.....	.....	9,000,000
*N. Y. Telephone Co.	.....	.....	8,747,000
*Board of Water Supply ..	.....	.....	9,258,000
*Public Service Commission	.....	.....	13,700,000

For Washington, from the statement of Mr. Sawtielle of the Board of Health, Washington.

For Tampa, Savannah, Jacksonville and Charleston, from the statement of local engineers checked against the figures of the United States Census of 1910.

For Boston, as follows, from figures published in the report of the Boston Metropolitan Water & Sewerage Board 1910.

TABLE NO. 5.

	Contributing.	Total.
N. Metropolitan District	465,000	524,000
S. " "	230,000	360,000
Boston Main Drainage District	470,000	**487,000
	1,165,000	1,371,000

B. The Population Contributing Sewage. Col. 3, has been estimated as follows:

For Havana from the statement of Mr. H. E. Hyde, of the Obras Publicas, Havana.

* All estimates marked thus made before 1910 census were available.

** Deducting 183,000 population of Boston tributary to the Metropolitan Sewer System, from the 1910 Census population of Boston. (670,000—183,00 = 487,000).

72 For New York, by assuming 80 per cent of the total population to be connected to sewers.

For Baltimore, as follows:

Total area of the city.....		19,200	acres
Area of the densely built up portion of the city, 50%, or.....		9,600	"
Population	558,000		
	558,000		
Density	$\frac{558,000}{9600}$ =	58	per acre
Area tributary to North West Harbor		5,000	acres
Population in this area 5000x58..	= 290,000		
50% assumed connected to sewers 290,000 x 50%	= 145,000		population contributing sewage.

For Washington, by assuming 90 per cent of the total population to be tributary to sewers connected with the main sewage outfall.

For Boston, see Table No. 5, Page 71.

For Savannah, estimate of Mr. John W. Howard, City Engineer of Savannah.

For Jacksonville, estimate of Mr. R. N. Ellis, Supt. Water Electric Light and Sewers, Jacksonville.

For Charleston, Dr. J. M. Green, Health Officer, Mr. Dunlop of City Engineer's office and Mr. J. M. Diven, Supt. of the Water Company. The total number of houses is approximately 9,000, of which 6,000 have privy vaults or dry closets. There are probably 3,000 houses connected to the sewers and the total population, $59,000 \times \frac{3000}{9000} = 19,700$ population contributing sewage.

(Here follows table marked Exhibit N, page 73.)

(Exhibit N 1.75)

- TABLE No. 6. -
GROSS AND PER CAPITA CONSUMPTION OF WATER AT VARIOUS PLACES WITHIN THE METROPOLITAN DISTRICT OF NEW YORK.

Place	Per Capita Consumption (Gals. Daily)	Population	Total Consumption (Million Gals. Daily)
(1)	(2)	(3)	(4) = (2) × (3)
Greater New York	114.0	4,766,883	545.0
Yonkers	103.0	79,803	8.2
Mt. Vernon	100.0	30,919	3.1
Newark	98.0	343,994	33.7
Jersey City	150.0	267,779	40.1
Paterson	80.0	125,600	10.0
Hoboken	114.0	70,324	8.0
Elizabeth	82.0	73,409	6.0
Passaic	79.0	54,773	4.3
Harrison	124.0	14,498	1.8
Kearney	102.0	18,659	1.9
East Orange	90.0	34,371	3.1
Bayonne	118.0	55,545	6.5
White Plains	80.0	15,045	1.2
Totals		5,961,602	672.9
Average	112.5		

Exhibit O.--(178)

Data on The Infiltration of Ground Water into Sewers.

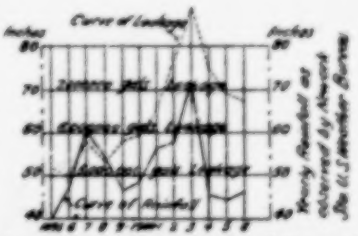


Diagram showing relation between rainfall and leakage into municipal sewage works as computed from records of flow of Union Outlet sewer from Orange, Montclair, Glen Ridge, and Bloomfield, N. J.

Passaic Valley Sewerage Comm. Report of Dec. 1907, page 11.

Table Showing Probable Leakage of Ground Water into Sewers of Orange, Montclair, Bloomfield & Glen Ridge from 1895 to 1906.

Date	Probable Leakage in Mill. Gals. / Day	Probable Leakage Gals. / Capita per day	Rainfall Inches per Year.
1895	52	87	49.83
96	50	84	46.68
97	582	97	60.69
98	537	88	54.17
99	5.04	97	45.68
1900	589	98	48.80
01	648	108	55.84
02	758	126	56.79
03	900	150	70.90
04	748	125	44.80
05	691	115	43.72
06	670	112	45.63
Ave.	643	107	51.14

Assumed population of 60,000, based on proportional population connected to sewers is the same (60%) in 1910 as in 1906.

Table taken from Passaic Valley Sewerage Commission report of December 1907. Page 13.

Data on Infiltration of Ground Water into Sewers

	Place	Size of Sewer	Length of Sewer Tributary to Section	Percentage of Sewage to Ground Water	Average Daily Flow of Sewage in Gallons	Average Rate of Infiltration per Inch Diameter per Mile per Day	Total Drainage in gals. per day	Remarks
1	Boston, Mass.	6'-10"	157		96000	50	5490000	Before any connect. to sewer.
2	Mass. State		100		80000	100	10,000,000	Loosely jointed section. Reported per mi. of sewer
3	Kalamazoo, Mich.			80%				Before any connect. to sewer.
4	Norfolk, Va.			40%		100		
5	Schenectady, N.Y.			5%				Not grouted and quick sand
6	Canton, O.		11		84500	0.68	13000	
7	Houston, Mass.	24		20%				Passing through swamp
8	North Brookfield, Mass.	10"	0.2		17000	71	3500-15000	
9	Rogers Park, Ill.	6	1.7		1240	0.2	2100	Bays closets and cellar sewage to main sewer
10	Brockton, Mass.		16		25500	31	400,000	
11	Alhambra, Cal.	27"	1.8		62500	0.65	97500	
		30"	0.4		86,250	0.65	82,350	
		36"-42"	0.55		245,000	0.60	252,340	[illegible]
12	East Orange, N.J.		29		32,400	0.63	650,000	[illegible]
13	East Orange, N.J.		25		8,700	0.10	212,500	
14	Joint Trunk Sewer Bd. of Sewerage Comm. Orange, Montclair and Glen Ridge		150	10%	00000	80	3,500,000	Glacial drift and quicksand
15						100	6,432,000	Average for years of 1898 to 1905

(Schedule B - 9 of 9)

74 For Tampa, from the estimate of Mr. F. F. Warner, City Engineer of Tampa.

C. The Daily per Capita Volume of Domestic Sewage, Col. 5, is estimated as follows:

For Havana, it is assumed to be equal to the daily per capita consumption of water, as stated by Mr. H. E. Hyde of the Obras Publicas, Havana.

For Baltimore, it is assumed to be equal to the daily per capita consumption of water as shown in the records of the Baltimore City Water Department.

For New York, Table No. 6, opposite, shows the daily per capita consumption of water in various communities within the Metropolitan Sewerage District. The average daily per capita consumption of water is shown by this table to be 112.5 gallons; 113 gallons per capita daily has been assumed to be the volume of domestic sewage to be expected within the district.

It is a recognized fact that the per capita consumption of water increases as the total population increases, and a daily sewage flow of 130 gallons per capita has been estimated for the New York Metropolitan District in 1940.

For Tampa, 125 gallons per capita daily is assumed as a conservative estimate of the sewage discharged by a city of the size and character of Tampa.

For Savannah, Jacksonville and Charleston, the volume of sewage per capita daily is assumed to equal the daily per capita consumption of water which has been computed from data supplied by Mr. John W. Howard in Savannah, Mr. R. N. Ellis in Jacksonville, and Mr. J. M. Diven, Supt. of the Charleston Light and Water Company.

75 For Washington and Boston, the method of determining the amount of domestic sewage is included in the explanation of the total volume shown in Col. 8.

D. The Volume of Manufacturing Waste Derived from Private Water Supplies, Col. 6, has been estimated from careful consideration of the manufacturing and water supply conditions in the several cities.

E. Infiltration of Ground Water, Col. 7.

The curve and tables following Pages 76-77, show that ground water may leak into a sewer in quantities ranging from 2 to 442 gallons per day per capita of population served by the sewer. From a careful study of the tables, 50 gallons per capita daily has been assumed to be a fair average value.

In the case of Washington and Boston no infiltration is shown, as it is included in the volume of sewage shown in Col. 8.

(Here follow tables marked Exhibits O and P, pages 76 and 77.)

78 F. The Total per Capita Daily Volume of Sewage, Col. 8.

For Washington, the volume of 218 gallons per capita daily has been computed from the records of sanitary sewage and storm water pumped to the main sewer outlet during the year 1910-1911. See "Report of the Operations of the Engineer Department of the District of Columbia, for the fiscal year ending June 30, 1911," page 156.

For Boston, the volume was estimated as follows from data presented in the eport of the Metropolitan Water and Sewerage Board for 1910."

Sewer System.	Outlet.	Flow in gallons daily.
North Metropolitan,	Deer Island	60,000,000
South "	Nut or Peddock's Island	40,000,000
*B. M. Drainage	Moon Island	105,000,000
		205,000,000

* Mr. X. H. Goodnough, on Page 416 of the Report of the Mass. State Board of Health, 1905, states the discharge from Moon Island to be 100,000,000 gallons daily in 1905. Increasing this volume in proportion to the increased population, it becomes 105,000,000 gallons in 1910. In 1905 the population contributing sewage to the Boston Main Drainage System, having its outlet at Moon Island, was, 615,000—156,000 = 459,000. (See Report of Metropolitan Water and Sewerage Board, 1905, Page 144.) 100,000,000 ÷ 459,000 = 223 gallons per capita. 223 x 470,000 = 105,000,000. (See Table 25, Page 71).

	Sewage per capita.	
	Contributary population.	Total population.
North Metropolitan	129.0 G. D.	114.5 G. D.
South "	174.0 " "	111.0 " "
Boston Main Drainage	233.0 " "	218.0 " "
Average	175.0 " "	148.0 " "

(Here follows table marked Ex. Q, page 79.)

- TABLE Nº 7. -
ESTIMATED TOTAL DRY SLUDGE OR SUSPENDED MATTER IN VARIOUS SEWAGES

Place	Parts per Million	Grams per capita daily	Tons per million gallons	Tons per 1000 population per annum
	(1)	(2)	(3)	(4)
* Framingham, Mass.	289	80	1.20	32
* Gardnier, Mass.	102	38	0.42	15
* Marlboro, Mass.	68	29	0.28	12
a Brockton, Mass.	195	26	0.82	10
* Worcester, Mass.	360	202	1.50	81
b Columbus, Ohio	215	98	0.89	39
a Providence, R.I.	397	141	1.67	56
c Philadelphia, Pa	180	—	0.76	—
a Boston, Mass.	149	125	0.63	50
d Paterson, N.J.	144	68	0.60	27
Av. of last six largest cities	240	127	1.01	50

(Exhibit G — p 178)

* From paper by Geo. W. Fuller, Trans Am Soc C.E., Vol. LIV, page 166
a "Sewage Disposal" Hennicutt, Winslow, and Pratt - pages Band 7
b Report on Sewage Purification of Columbus, Ohio - 1905 - page 32
c Report of Bureau of Surveys, Comprising Work at Sewage Experiment Station 1911 - page 200
d Report on Sewage Disposal - Paterson, N.J. 1906 Appendix N - page 19

TABLE No. 8.

RATIO OF TOTAL SOLIDS TO SUSPENDED MATTER IN SEWAGES.

Place	Population	Parts per Million		Ratio
		Total Dry Solids	Suspended Matter	
(1)	(2)	(3)	(4)	(5)
Framingham, Mass.	12,948	601	289	2.08
Gardnier, Mass.	14,699	287	102	2.81
Marlboro, Mass.	14,579	300	68	4.41
Brockton, Mass.	56,878	818	195	4.14
Boston, Mass.	671,000	——	149	——
Philadelphia, Pa.	1,549,000	——	180	——
Paterson, N.J.	126,000	319	144	2.14
Providence, R.I.	224,000	1715	397	4.29
Worcester, Mass.	146,000	908	360	2.33
Columbus, Ohio	182,000	1026	215	4.77
Aver. of last four largest cities				3.38

(Babbitt & Hoskins)

TABLE No 9
RATIO OF
WET SLUDGE AND DRY SOLIDS
DEPOSITED PER MILLION GALLONS OF SEWAGE.

(Eng. News Vol. 71 P. 1178)

Where Collected	Authority	Tons of Wet Sludge	Tons of Total Dry Solids	Ratio
(1)	(2)	(3)	(4)	(5)
In Grit Chambers	Report on Columbus, Ohio, Sewage Purification; - 1905 - page 86.	2.27	0.29	7.83
		1.61	0.28	5.75
In Sedimentation Tank	Report on Columbus, Ohio, Sewage Purification; - 1905 - page 101	2.97	0.36	8.25
		3.29	0.38	8.66
		3.22	0.33	9.76
In Sedimentation Tanks	Report of Bureau of Surveys on Sewage Experiment Station, Philadelphia Pa. 1910 - Table 16 - Page 36.	4.28	0.428	10.00
		3.56	0.443	8.00
			Average	8.32

80 APPENDIX III.

Basic Data for Estimating Tons of Wet Sludge per Million Cubic Feet of Sewage.

Table No. 7 gives the estimated total suspended matter in various sewages. The average of the six largest cities given in Col. 4 is 50 tons per 1,000 population per annum, which is the figure used in the report.

Table No. 8 gives the ratio of total dry solids to suspended matter in various sewages. The average ratio of the four largest cities is 3.38.

Table No. 9 gives the ratio of wet sludge to total dry solids, the average being 8.32.

We have assumed, therefore, 50 tons of suspended matter per 1,000 population per annum $\times$ 3.38 $\times$ 8.32 = 50 $\times$ 28.12 = 1,406 tons of wet sludge per 1,000 population per annum. Assumed population for New York—6,000,000 gross tons sewage sludge in 1911 = 6,000 $\times$ 1,406 = 8,436,000 tons, or approximately 9,540,000 cubic yards.

(Here follow tables marked Exhibits R and S, pages 81 and 82.)

83 APPENDIX No. IV.

Laboratory Methods and Experiments.

Although the methods employed by your committee in the examination of the water and muds from the various harbors considered are all well known and in general use, it is deemed advisable to give a brief description of them, together with a description of one or two studies made during the investigation.

The usual examination consisted of the determination of the temperature, dissolved oxygen, salinity and turbidity of the water and degree of putrescibility of the mud. A study was made to determine the relative value of different methods for the determination of dissolved oxygen, and a series of tests was made to determine the effect of varying quantities of nitrites on the accuracy of the "Winkler" method for the determination of dissolved oxygen.

Dissolved Oxygen.

The amounts of dissolved oxygen in the waters of New York Harbor have been taken from the figures presented by the Metropolitan Sewage Commission and given in their report. The method employed by that commission for the determination of dissolved oxygen was the "Levy" method.

The samples of water examined from harbors other than at New York were collected with the apparatus carried by your committee, and the quantity of dissolved oxygen was determined by both the "Levy" and the "Winkler" methods. These methods are described in detail at another point in this appendix. The results of these examinations showing the oxygen dissolved in the various harbor waters are given in the tables on pages 62 to 68.

84 Salinity.

The salinity of the various harbor waters examined was ascertained by the determination of the amount of chlorine present in the water. The chlorine was determined according to standard methods by titration with a solution of silver nitrate (2.4 grams per liter) using potassium chromate as an indicator.

Turbidity.

The turbidity of the water in the various harbors examined was determined by use of the United States Standard Turbidity Rod. In some few instances when no rod was available the turbidity was taken with a rule graduated in inches, and the reading calculated to parts per million by aid of the standard table. The turbidities at various points in the different harbors are shown on the tables pages 62-68.

Putrescibility of Muds.

The method used in determining the putrescibility of the mud from the bottom of the various harbors is that devised by one of this committee (D. D. Jackson) and W. A. Horton and published in the Journal of Industrial & Engineering Chemistry, June 1909 and which depends upon the decoloration of an organic dye by putrescible substances in the absence of available oxygen. The method as used is as follows:

Solutions of mud in various proportions are made by adding a definite weight of the wet mud to varying quantities of distilled water saturated with air at the room temperature (about 20° C.). One c. c. of methylene green (½ gram per liter) is added to each liter of the various dilutions. An eight ounce bottle is filled with the dyed solution of mud and a rubber stopper fitted with a short tube and rubber bulb, also filled with the mud solution, is
85 inserted in such a way that no air bubbles are enclosed. The water in the rubber bulb is then forced out, leaving the bulb collapsed. The bottle is now placed in the 37° incubator and allowed to remain at that temperature for four days. As fast as the solution in the bottle expands, because of the increase in temperature, the increase fills the rubber bulb. In this manner no solution escapes and no air is brought in contact with the solution after the test begins.

As soon as the oxygen dissolved in the solution is consumed by the organic matter in the mud, the dye present is attacked and the color disappears. This disappearance of color therefore indicates a putrescible condition and a higher dilution must be examined.

A sample of the wet mud is dried at 100° C. for one hour and the percentage of moisture determined. From this the actual weight of dry mud used may be determined and the correct degree of putrescibility may be figured.

The samples taken in New York Harbor were collected with a piece of apparatus shaped like a mushroom anchor weighing about ten (10) pounds and having a head twelve (12″) inches in diameter and six (6″) inches deep. The mud was obtained by dragging this anchor on the bottom of the harbor for a few feet and then bringing it to the surface. The results of these tests are given in the table on page 69, of Appendix I.

A Comparison of Various Methods for the Determination of Dissolved Oxygen in Sea Water.

Considerable discussion has arisen recently concerning the relative accuracy of various methods for the determination of dissolved oxygen in sea water. In order to convince ourselves on this
86 point, studies were made comparing the various methods.

Apparatus.—The apparatus used in the collection of samples of water from New York Harbor consisted of a container holding three separatory funnels of about 300 c. c. capacity and having

a small bulb in the stem and a two liter bottle. The container was weighted so that it would sink readily. The funnels and large bottle were so connected that the water was taken from a common point and passed through the funnels into the bottle. When the large bottle was filled the water in the small funnels had been changed several times thus securing a uniform sample free from contact with the air.

As soon as the container was brought to the surface the filling tubes were removed and stoppers inserted in the funnels, care being taken that no air should remain in the funnel. The tests were made as soon as the samples reached the laboratory which was not more than ten minutes from the time they were taken.

One funnel was used in making a test by the "Winkler" method and the other two were used in making a test by either the "Levy" or "Letts-Adeney" methods.

The methods used in making the determination of oxygen dissolved in sea water are known as the "Winkler" method, the "Levy" method and a third method referred to as the "Letts-Adeney" method and described in the Fifth Annual Report of the Royal Sewage Commission, Appendix 6, Pages 221-224.

Briefly described the methods are as follows:

Winkler Method.—The stopper is removed from one of the full separatory funnels and two c. c. of manganeous sulfate solution (48 grams to 100 c. c. of water) and two c. c. of sodium hydrate and potassium iodide solution (360 grams of hydrate and 100 grams of iodide to 1000 c. c. of water) are delivered at the bottom of
87 the funnel. The stopper is again inserted and the solutions thoroughly mixed. After standing for five minutes in the inverted funnel, four (4) c. c. of sulfuric acid (1:1) are admitted to the funnel through the stem. The acid dissolves the precipitate formed. The contents of the funnel plus the liquid replaced by the acid is rinsed into a half liter bottle and titrated with $\frac{N}{40}$ solution of sodium thiosulfate using five (5) c. c. of starch solution near the end of the titration as an indicator.

The calculation of the results is made from the formula as given on page 76 of the Report of the Committee on Standard Methods. Oxygen in parts per million $= \frac{200\ N}{V}$ where "V" is the capacity of the funnel, in c. c., less the volume of manganeous sulfate and potassium iodide solution added (less four c. c.). "N" is the number of c. c. $\frac{N}{40}$ sodium thiosulfate solution used in the titration.

Levy Method.—Six (6) c. c. of ferrous sulfate solution (48 grams of salt and five (5) c. c. of sulfuric acid per liter) and four (4) c. c. of sodium carbonate solution (200 grams per liter) are introduced at the bottom of the separatory funnel. The stopper is inserted and

(Exhibit T #174)

RELATIVE RESULTS OBTAINED
WITH
LETTS-ADENEY AND THE WINKLER METHODS FOR THE DETERMINATION
OF
DISSOLVED OXYGEN IN THE WATERS OF NEW YORK HARBOR

Date	Temp. °C	Tide	Chlorine	Nitrites	Oxygen Dissolved		% Saturation	
					Letts-Adeney	Winkler	Letts-Adeney	Winkler
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(9)	(8)
1-31-12	0	Flood	13,200	.016	11.73	10.15	94.29	81.59
2-1-12	0	"	12,900	.014	4.59	8.52	36.75	68.19
2	0	"	13,500	.016	20.40	10.72	164.63	86.52
5	0	Ebb	12,300	.018	12.75	10.43	101.27	86.02
6	0	"	15,600	.020	7.33	10.29	61.70	86.62
8	0	"	14,800	.011	—	10.37	—	85.23

RELATIVE RESULTS OBTAINED
WITH
THE LEVY AND THE WINKLER METHODS FOR THE DETERMINATION
OF
DISSOLVED OXYGEN IN THE WATERS OF NEW YORK HARBOR

Date	Temp. °C	Tide	Chlorine	Nitrites	Oxygen Dissolved		% Saturation	
					Levy	Winkler	Levy	Winkler
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1-9-12	2	Flood	12,350	.016	11.22	9.16	90.66	73.75
10	0	"	8,800	.016	9.94	9.18	74.03	80.16
11	0	Ebb	11,500	.015	12.24	10.65	96.23	83.73
12	0	"	13,850	.010	12.24	10.70	99.19	86.71
13	0	Flood	13,000	.011	11.22	10.37	89.98	83.16
15	0	"	14,100	.016	9.69	9.30	78.84	75.67
16	-2	"	13,300	.016	15.30	10.68	123.19	85.18
17	0	"	12,100	.020	11.73	9.59	94.53	75.99
18	0	"	14,000	.012	11.22	10.61	93.75	86.70
19	0	"	15,500	.021	10.71	9.37	88.81	77.28
22	0	Ebb	13,000	.016	10.71	9.44	90.53	79.79
23	0	"	13,100	.014	10.71	9.30	86.03	74.70
24	0	"	12,500	.018	11.22	7.88	89.33	67.74
25	0	"	13,500	.016	9.18	9.23	74.09	75.30
26	0	"	13,000	.030	9.16	9.59	73.62	76.90
29	0	Flood	13,800	.018	12.24	9.73	99.19	78.85
30	0	"	13,500	.020	11.75	9.66	94.67	77.99
2-14	10	"	13,200	.016	6.05	6.52	61.25	66.27

the contents of the funnel thoroughly mixed. The funnel is then inverted and allowed to stand for five minutes. Ten (10) c. c. of sulfuric acid (1:1) are then admitted to the funnel through the stem. As soon as the precipitate is dissolved and the solution is colorless, the contents of the funnel are rinsed into a half liter bottle and titrated with standard potassium permanganate solution, made by dissolving 5.638 grams of salt in 1000 c. c. of water. One (1) c. c. of this solution is equivalent to one (1) c. c. of oxygen under normal conditions of temperature and pressure.

88 A blank test to determine the value of the ferrous sulfate solution is made by repeating this method with another funnel, but adding the sulfuric acid before the ferrous sulfate or sodium carbonate.

The result is calculated by subtracting the number of cubic centimeters of potassium permanganate required in the titration of the sample, from that required by the blank. This number divided by the volume of the funnel and multiplied by 1000 equals the number of c. c. of oxygen per liter of water and this multiplied by 1.434 equals parts per million.

Letts-Adeney Method.—Seven (7) c. c. of the sample are removed from the separatory funnel and five (5) c. c. of ferrous sulfate solution (48 grams per liter) are introduced at the bottom of the funnel. Strong ammonia is added until the funnel is full and the stopper is replaced, care being taken that no bubble of air is enclosed. The liquids being of different specific gravities the ferrous sulfate solution remains at the bottom of the funnel and the ammonia is at the top. When the funnel is agitated the liquids mix and a precipitate is formed. The funnel is inverted and allowed to stand for five minutes. Ten (10) c. c. of sulfuric acid (1:1) are then applied through the stem and when the precipitate has dissolved the whole is rinsed into a half liter bottle and titrated with standard potassium bichromate solution made by dissolving 8.7906 grams of salt in one (1) liter of water. Each c. c. of this solution is equivalent to one cubic centimeter of oxygen at normal temperature and pressure. The titration is made using potassium ferricyanide as an indicator.

(Here follow tables marked Exhibits T and U, pages 89 and 90.)

91 A blank test is made using a separatory funnel in the same manner as above but adding the sulfuric acid before the ferrous sulfate ammonia.

The result is calculated to parts per million by the same method as that used in the "Levy" method.

Comparison of Results.

Twenty-four (24) tests were made in the study to determine the relative accuracy of the various methods for the determination of dissolved oxygen. Eighteen (18) were made comparing the "Winkler" and "Levy" methods and six (6) comparing the "Winkler" with the "Letts-Adeney" method. The results expressed in parts per million and in per cent saturation together with the temperature, condition of tide, and amount of nitrite and chlorine present are recorded in the accompanying table.

The water used in these tests was taken from the East River at the outer end of Pier 15. This sampling point was chosen in view of the fact that a large sewer empties into the river under this pier, and the water at this point would therefore contain a high amount of organic matter.

It will be noted from the table of results that with the exception of two tests the "Levy" method yields higher results than does the "Winkler." Sometimes the "Levy" method produces a result so high as to indicate super-saturation. This seems highly improbable even at the low temperature, when the high amount of organic matter known to be present is taken into account.

92 The average difference in the per cent saturation between the two methods is 12.42%. The average difference expressed in parts per million is 1.59.

The effect of slight variations in the titration by either method may best be shown in the form of a table as follows:

Method.	Volume of reagent used.	Equivalent to parts per M.	% saturation at 0°C 15.300 parts per M., of chlorine.	Difference in % saturation, due to 0.1 c.c.
Winkler	14.1	10.01	80.59	0.56%
	14.0	9.94	80.03	
Levy	2.2	11.22	90.35	4.12%
	2.1	10.71	86.23	

It also appears that one (1) part per million corresponds to a difference of 8.23% in percentage of saturation with the conditions of temperature and salinity under which these tests were made. With higher temperature conditions the difference would be even greater.

The difference between the results obtained with the Winkler and Letts-Adeney methods are greater than the difference between the Winkler and Levy methods. Difficulty was also encountered in obtaining a satisfactory end point in several tests so that it was concluded that nothing was gained by using this method.

EFFECT OF NITRITES
ON THE
ACCURACY OF THE WINKLER METHOD FOR THE DETERMINATION OF DISSOLVED OXYGEN

A. DISTILLED WATER				B. N.Y. HARBOR WATER			
Nitrite Present	Dissolved Oxygen	Nitrite Present	Dissolved Oxygen	Nitrite Present	Dissolved Oxygen	Nitrite present	Dissolved Oxygen
.000	9.39	.010	9.30	010	7.97	.105	7.88
.001	9.34	.020	9.19	020	7.36	.115	7.83
.002	9.24	.030	9.34	040	7.82	.125	7.80
.003	9.23	.040	9.16	060	7.84	.015	7.91
.004	9.24	.050	9.19	020	7.81	.315	7.79
.005	9.24	.100	9.24	040	7.83	.025	6.13
.006	9.23	.200	9.16	055	7.48	.415	0.86
.007	9.19	.500	9.67	085	7.83	1.015	0.26
.008	9.26	.800	10.05	095	7.81		
.009	9.00	1.000	10.10				
.010	9.31	2.000	10.01				
.012	9.26						

Results expressed in Parts per Million.

Distilled Water saturated with oxygen at 19°C
Containing 9.37 parts per Million.

Results expressed in Parts per Million.

Nitrite originally present = .015
Chlorine present = 13,200

Sea Water saturated with oxygen at 19°C
Containing 8.6 parts, Million.

The results and conclusions of the Central Committee are based on determinations made by the Levy method. It would seem from our experiments, made with these methods, that the true percentage of dissolved oxygen may be lower than that deduced by the Metropolitan Sewerage Commission from determinations by the Levy method.

(Here follows table marked Exhibit V, page 93.)

94 *The Effect of Nitrites on the Accuracy of the Winkler Method for the Determination of Dissolved Oxygen.*

Several investigators have stated that the accuracy of the Winkler method for determination of dissolved oxygen was impaired when nitrites were present. In order to determine the extent of the effect of nitrites on this method, a series of tests was made, using distilled water charged with oxygen, and salt water as taken from New York Harbor.

This salt water as collected contained 13,200 parts per million of chlorine and .015 parts per million of nitrites. It also contained 7.47 parts per million of dissolved oxygen. Standard solutions of potassium nitrite were prepared of such strengths that one (1) c. c. diluted to one hundred (100) c. c. increased the nitrite present by 1.000, 0.100, 0.010 or 0.001 parts per million. Since the salt water used in the tests had .015 parts per million of nitrites ordinarily present, it was impossible to determine whether this initial amount was sufficient to effect the determination of dissolved oxygen. In order to settle this question, distilled water free from nitrites and aerated until it was practically saturated with oxygen, was used for a second series of determinations.

The results of these tests are given in tabulated form in the table on page 93. It will be seen from this table that nitrites present in quantities of less than 0.500 have no effect on the determination of dissolved oxygen by the Winkler method. Since this quantity of nitrites is very rarely, or never present in waters to be examined for dissolved oxygen it appears from the studies here described that the Winkler method may generally be used without regard for the composition of the water.

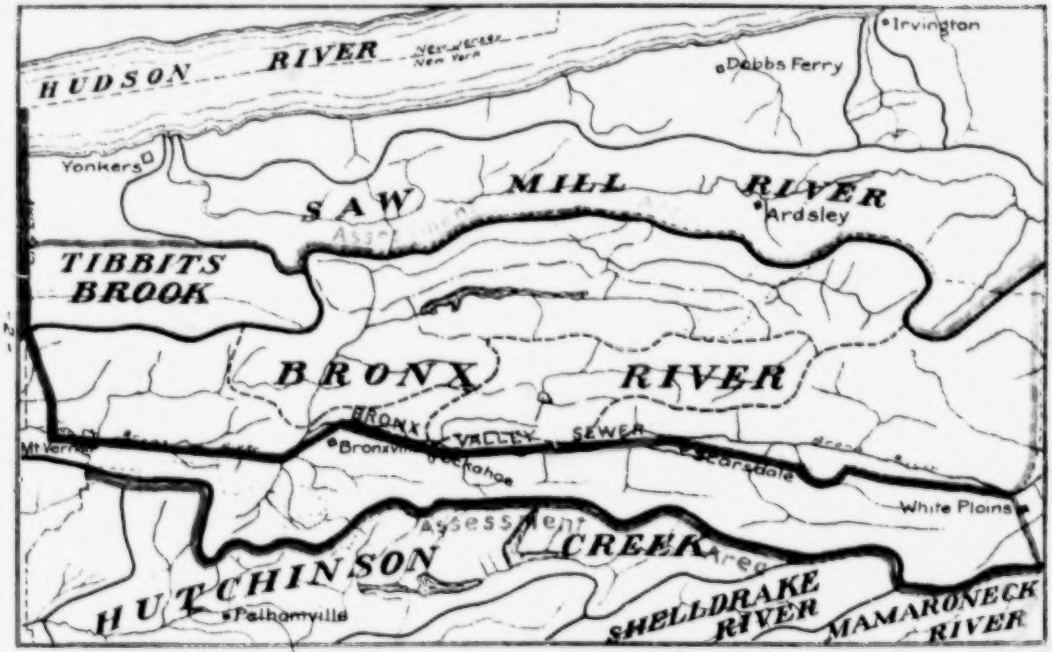
THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOW COMPLAINANTS' EXHIBITS Nos. 179 and 180.

JAMES D. MAHER,
Commissioner.



Complainants Exhibit No. 179
James D. Mader

187

TABLE

PAST, PRESENT AND ESTIMATED POPULATION OF BRONX VALLEY SEWER AND CIVIL DIVISIONS LYING WHOLLY OR PARTLY

Name of Civil Division	Period Considered	Population at Earliest Date Named in Col. #2	Population at Latest Date Named in Col. #2
(1)	(2)	(3)	(4)
City of Yonkers	1880-1910	18,892	79 803
City of Mt Vernon	1880-1910	4,586	30 919
Town of Eastchester	1900-1910	3,039	6 422
Town of Scarsdale	1880-1910	614	1 300
Town of Greenburgh including portion of White Plains Village	1880-1910	8,934	23 193
Town of White Plains excluding White Plains Village	1890-1910	689	1 141
Village of White Plains portion of, lying in White Plains Town	1880-1910	2,381	13 904
Total or Average			156 682
Bronx Valley Sewer Assessment Area	1906-1910	32,212	49,000
Borough of Bronx	1867-1905	32,500	305 000
Borough of Queens	1860-1912	32,903	310 523

221 *
13.8 * } These figures indicate growth for period in col. #2. and are presented for purposes of comparison

No 12.-

ED FUTURE POPULATION

ASSESSMENT AREA

OF THE

WITHIN THE ASSESSMENT AREA

Supplementary to Exhibit No. 180

James L. Maher

Commissioner.

Population 1920	Population 1930	Population 1940	Population 1950	Average Per Cent of Annual increase based on initial population given in Col 3
(5)	(6)	(7)	(8)	(9)
122 183	175 652	242 199	334 178	23.8
41 190	51 460	61 730	72 000	21.0
11 201	20 334	35 988	53 982	33.5
2 078	3 627	6 337	10 965	24.1
31 037	42 801	59 357	81 972	11.7
1 656	2 820	4 673	7 277	15.9
22 402	31 032	39 662	48 052	27.4
231 747	327 726	449 946	608 426	20.8
96 346	143 072	214 188	303 163	19.11
				22.1 ■
				13.5 ■

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 181.

Shellfish Investigation in Raritan Bay by New York State Department of Health.

JAMES D. MAHER,
Commissioner.

833 COMPLAINANT'S EXHIBIT No. 182. James D. Maher, Commissioner.

Sanitary Inspection of Shellfish Grounds.

One of the most important investigations carried on during 1908 and the one requiring the greatest amount of time and attention from the Engineering Division was an examination into the sewage pollution of those waters of the State in which shellfish are grown and matured.

This work, undertaken in accordance with the provisions of section 214 of the Forest, Fish and Game Law, was begun in the latter part of June, 1908, and occupied the time of one engineer and two special inspectors of the division for the greater part of the months of July, August and September. This investigation was made in co-operation with the hygienic laboratory and the work performed by the Engineering Division comprised detailed inspection and the collection of necessary data showing the extent and character of pollution discharged into the streams, bays and sounds of Long Island, comprising some 400 miles of shore line, together with such detailed inspection along the southeasterly shore of Staten Island. In addition to these statistics the location of leased oyster beds was procured from the Department of Marine Fisheries of the Forest, Fish and Game Commission, from the local authorities of various towns along the shores and from the county of Suffolk.

From the information thus collected a set of maps has been prepared showing by an appropriate index pollution data reported by the inspectors together with the location of leased oyster beds. On these maps appear, also, the position and number of the sampling stations from which samples for analysis of both water and oysters were procured and made by the laboratory division.

The results of the investigation have been summarized and described in the following report submitted in accordance with the provisions of the special act to the State Superintendent of Marine Fisheries:

834 ALBANY, N. Y., February 11, 1909.

Hon. B. Frank Wood, Superintendent of Marine Fisheries, Department Forest, Fish and Game, 1 Madison Avenue, New York, N. Y.

DEAR SIR: Section 214 of the Forest, Fish and Game Law requires that reports of the results of inspections of shellfish beds and shellfish made by inspectors of this Department, in obedience to sections 214 and 215 of the same law, shall be submitted to you "immediately."

The person or persons responsible for the drafting of these provisions were possibly under the impression that mere inspection of shellfish beds and the surroundings of the shellfish thereon would give sufficient evidence upon which an opinion as to their sanitary quality, that is fitness for food, could be expressed.

It is unfortunate, but nevertheless true, that such an inspection

as apparently was considered all that would be necessary would be of practically no value in giving results which could be relied upon for the determinations in question.

Only the most exhaustive study of the sanitary conditions of the waters, which might from time to time be over the shellfish beds, and the thorough investigation of all the possible sources of pollution of such waters, together with the determination of all the periodic and special conditions of tides, currents, variations of level, etc., added to and interpreted in the light of the findings of laboratory analyses and examinations of these waters and of the shellfish from these beds, would give any results upon which a satisfactory and fair determination as to sanitary conditions of the shellfish might be based.

Moreover, there is a further difficulty inherent in the State of our scientific knowledge regarding the relation of oysters to the transmission of water-borne diseases, especially typhoid fever. This is that no scientific or administrative body of all those who have made investigations in this direction, even over long periods and with ample scientific assistance, has as yet determined to its satisfaction any definite relation between any estimated pollution of water or of shellfish and the disease-producing liability of the pollution in such water or shellfish.

835 These difficulties, however, did not lessen the efforts put forth by this Department on this work during the last few months, but they have been conducted to the full limit of its capacity, consistent with its other imperative duties. In order, however, that the results may be placed before you in a manner carrying conviction of our earnest desire and intention to fully comply with the law, consistent with a strict adherence to the known scientific possibilities of the situation, an introduction to the main body of the report referring to these difficulties and to our present knowledge on the subject is respectfully submitted.

This introduction deals as briefly and yet as comprehensively as possible with the following subjects:

A. Our knowledge regarding the relation of the occurrence of typhoid and other infectious diseases to the eating of oysters and shellfish.

B. The results and the interpretations of investigations of the sanitary conditions of shellfish grounds, layings, etc., and the shellfish from the same, including the quotation of opinions of scientific workers and commissions regarding the present difficulty, if not impossibility, of fixing standards of pollution upon which condemnations may be based.

A. Relation of Oysters and Shellfish to the Causation of Typhoid Fever.*

Long before the advent of the science of bacteriology there were evidences to show that oysters grown or fattened in sewage-polluted waters were responsible for cases of typhoid fever in those who had eaten these oysters uncooked.

The earliest outbreaks of typhoid attributed to the eating of contaminated oysters were reported in 1816, but few other instances were placed on record until 1880. Since that date a con-
836 siderable number of definite outbreaks have been more or less conclusively shown to have been due to the eating of oysters and shellfish taken from polluted waters. In some places having a high incidence of typhoid fever investigators have attributed a considerable proportion of the sporadic cases of this disease, and in fact some have assigned actual endemic typhoid conditions to the eating of shellfish taken from polluted waters.

Concerning the evidence connecting some of the outbreaks of typhoid fever with the eating of oysters obtained from polluted waters there can be no serious question. That oysters obtained from or which have been "plumped" in sewage-polluted waters have caused outbreaks of typhoid fever is a fact which cannot be gainsaid.

The well-known outbreaks of typhoid fever attributed to oysters in this country occurred at Middletown, Conn., and at Atlantic City.

The Middletown outbreak occurred in the fall of 1894 and was responsible for commanding definite attention in this country to the transmission of typhoid fever by oysters from polluted waters.

The conditions and circumstances under which the outbreak occurred were exceptionally well adapted to prove the possibility and the probability of such transmission following certain lines of oyster industry.

The facts described by Conn* were substantially as follows:

Oysters taken from long Island sound were deposited for a few days, at least, in the tidal waters of Quinnipiac river at Fair Haven, Conn., about 300 feet above the outlet of a private sewer carrying sewage from a house in which there existed two cases of typhoid fever.

Some of these oysters were eaten raw at three separate fraternity banquets at Wesleyan University and served cooked at another fraternity banquet. All of these banquets were held the same evening. Twenty-five per cent. of those attending the three banquets where the raw oysters were served contracted typhoid fever. There

* In the Journal of the Franklin Institute, Vol. CLX, p. 81, August, 1905, Mr. George W. Fuller gives a full account and a very extensive bibliography of Sewage Disposal in Its Relation to the Pollution of Oysters and Shellfish and to the Transmission of Typhoid Fever by the Latter.

An exhaustive report on the same subject is to be found in the Fourth Report of the British Royal Sewage Disposal Commission, Vols. I, II and III.

* Conn. Seventeenth Annual Report, Connecticut State Board of Health, 1894, pp. 243-264.

were twenty-nine such cases. None of those attending the
837 other banquet were affected. There were likewise found two cases among those who had eaten oysters from the same lot in other places in Middletown.

Some of the oysters from the same location at Fair Haven were sent to an Amherst College fraternity dinner, held on the same evening, and six cases of typhoid fever among those attending followed.

No other cases occurred in either of these places which could not be satisfactory accounted for.

The period of incubation and the onset and course of the disease in these cases indicated most definitely a common origin, and there was found no other possible common source but the Fair Haven oysters.

This is a most typical example of the infection of oysters through "plumping" or "drinking" them in water polluted with typhoid discharges. The practice of "drinking" oysters at Fair Haven was not new at that time; the sewer responsible for the infection and other private sewers in the neighborhood had poured sewage into the river for years. The Quinnipiac is likewise polluted by sewage from other sources, but so far as is known the oysters plumped in its waters had not been responsible for a prior outbreak of typhoid fever. However, it would not be proper to infer that oysters plumped in these waters had not been the cause of cases of typhoid fever. Nevertheless, the advent of the two cases to one of the houses sewering into the river near the oyster floats brought about a pollution described by Houston as the most dangerous kind as it was "specific" in character and of "recent sort," although comparatively small in amount.

During the summer of 1902 at Atlantic City, N. J., an unusual number of cases of typhoid fever was noted by the medical profession of that place.

A thorough study of the situation showed that there was no common source for the infection other than oysters and clams. The oysters were found to have been floated in waters at the mouth of the Penrose canal and its vicinity, and this canal was ascertained to be carrying an unusual amount of sewage, owing to a break in the large sewer pipe running in the canal and which conducts
838 under ordinary conditions a considerable portion of Atlantic City's sewage to the "thoroughfare." That the oysters floated and the clams taken from these polluted waters were responsible for a large proportion of the unusual number of cases at Atlantic City there is no doubt. This conclusion was approved by several well-known bacteriologists and epidemiologists who investigated the situation.

In England, in recent years, two extensive outbreaks of typhoid fever, directly attributable to oysters, occurred at Winchester and Southampton from eating of raw oysters taken from lots floated in the proven polluted waters at Emsworth. Here, again, we have to deal with two banquets given on the same day in two separate municipalities, with no possible common source of infection other

than the oysters which were eaten raw. None of the guests contracted the disease except those who had eaten some of the oysters. Approximately, the same percentage of guests contracted the disease and at corresponding intervals. It was likewise found, as in the Middletown cases, that oysters from the same lot brought about infection with the disease among those eating them in other places. It is interesting to note that the oysters had been temporarily deposited in the polluted waters and had not reached maturity at this spot.

In the matter of the causations of sporadic cases and of endemic typhoid conditions by the eating of shellfish, the British Commission on Sewage Disposal obtained the opinions of a large number of well-known English bacteriologists and epidemiologists on the subject. The following are some of the more representative of these opinions, together with the final conclusion of the Commission:

"Dr. J. T. C. Nash.—From special researches made in 1902 into the causation of typhoid fever in Southend-on-Sea, Dr. Nash came to the conclusion that at least 50 per cent. of the cases in that year were due to the consumption of shellfish from sources contaminated by sewage. This, indeed, in his opinion, understates the limit, as he found that out of 105 cases of typhoid fever in that year there was some connection with shellfish in at least eighty-two cases.

"Dr. Nash also quoted figures of typhoid notification in Yarmouth for each month of the years 1897 to 1902. In 1900, after
839 a series of years of endemic typhoid in this town, the sale of mussels from the Yare was stopped, and in 1901, there was a marked reduction in the number of notifications (amounting to 30 per cent. below the monthly means of previous years), and in 1902 a still further reduction.

"Dr. A. Newsholme.—Submitted a tabular statement of the number of cases of enteric fever in Brighton during the years 1894 to 1902, distinguishing those which, in his opinion, were caused by oysters and other shellfish. This table indicates that, out of 643 cases, 158 cases were directly ascribable to the consumption of oysters, and eighty cases to the consumption of other shellfish within the period of incubation. In other words, that 37 per cent. of the total cases of enteric fever during these years were ascribable to shellfish. The history of each case was traced, and cases of typhoid fever were only put down to the shellfish after the apparent exclusion of every other possible cause. The shellfish were traced to particular layings which were proved to be exposed to sewage contamination, and typhoid fever was found to exist among the population draining to the vicinity of the layings. In the opinion of Dr. Newsholme, the extent of the illness attributable to shellfish is understated in the above figures.

"Dr. James Niven.—Submitted a tabular statement of the number of cases of enteric fever in Manchester during the years of 1897 to 1902, inclusive. This table shows that in that period there were 2,664 cases of enteric fever, of which number 274 were associated with the consumption of shellfish, 118 being strictly ascribable to mussels and oysters. In arriving at the latter figure, all other possible causes were considered, and all doubtful cases were rejected. Owing

to gaps in the figures, the number of cases due to shellfish is probably understated.

"Mr. Shirley Murphy.—The information supplied by medical officers of health of metropolitan boroughs tended to show that in 8 per cent. of the cases of enteric fever which occurred in London in 1902, the patient had eaten shellfish at a time before the attack that was consistent with such shellfish having been the cause of the disease. It was not possible, however, to make a definite statement as to what the proportion really was, and Mr. Shirley Murphy was inclined to think that 8 per cent. fell short of the number that
840 would have been obtained if full inquiries could have been made.

"Conclusion of Commission as to Extent of Illness Attributable to the Consumption of Contaminated Shellfish.

"29. After carefully considering the whole of the evidence on this point, we are satisfied that a considerable number of cases of enteric fever and other illness are caused by the consumption of shellfish which have been exposed to sewage contamination; but, in the present state of knowledge, we do not think it possible to make an accurate numerical statement.

"Moreover, an examination of the figures which have been placed before us as regards those towns in which the subject has been most carefully studied shows that there may be occasional errors. Indeed, the witnesses themselves recognized that absolutely accurate figures are not obtainable.

"We are far from denying that isolated cases may have been due to contaminated shellfish, but when we remember the numerous unexplained cases of enteric fever, we feel that the possibility of some of them being due to other causes cannot be altogether excluded."

In this county, opinion on this subject has not become sufficiently crystallized to have brought out many reports of investigation.

The most important is, perhaps, that made by Mr. George A. Soper* regarding typhoid conditions at Lawrence, L. I., in 1904. In this study, the investigator found twenty-one out of thirty-one cases of typhoid fever in which the only probable sources of infection were oysters and clams taken from floats immersed in polluted waters, or from oyster beds subject to pollution. In the majority of cases at least, the oysters were from the floats.

That the waters in which these floats were located were badly polluted was amply demonstrated by the chemical and bacteriological examinations made at a time when conditions were known to be far better than when the cases of the disease developed.

Samples of oysters were likewise examined bacteriologically, and of them 25 per cent. were shown to contain bacteria of the bacillus coli communis type in one-tenth of a cubic centimeter of
841 the shell water, and in 60 per cent. in one cubic centimeter of the same.

The sanitary survey showed the discharge of imperfectly treated sewage, from a population of 15,000, less than half a mile from the

* Soper. Medical News, Vol. 86, 1905, p. 241

oyster floats. In fact, some were very much nearer. Aside from this pollution, there were many individual sewers, manure piles, dump heaps, piles of cesspool sludge, which contributed to the pollution of the water adjacent to the floats.

B. The State of Our Knowledge Concerning the Relation of Qualitative and Quantitative Estimations of Pollution of Water and Shellfish to Disease-producing Liability of the Latter in Man.

From a study of the outbreaks of typhoid fever proven and suspected of being caused by oysters, and of endemic conditions and sporadic cases of this disease caused and suspected of being caused by the consumption of infected shellfish which have been already described, it is apparent that in almost all the instances quoted in the former group, and to a large extent those in the latter, were due to the almost direct carriage of materials of a demonstrated or readily assumed specific infectious typhoid or other disease-producing nature to the shellfish.

The fact that the great danger of the transmission of typhoid fever and other diseases by means of shellfish lies in the character of the materials polluting the beds, drinking places, etc., and in the directness with which such pollution reaches the shellfish, has been well expressed by Hanston in the Fourth Report of the British Royal Sewage Disposal Commission, Vol. I, p. 36, where he is quoted as saying as follows:

"A pollution trivial in amount but specific in character is much more dangerous than a contamination gross in amount but non-specific in nature.

"It is also probable that a pollution trivial in amount, but specific in character and of recent sort, is more dangerous than a pollution gross in amount, specific in character, but of remote kind."

If then the important factors in the role which shellfish play
842 in the transmission of diseases are the character of the materials polluting them and the directness of the pollution, it is manifest that to be in a position to definitely pass upon the disease-producing value of a given growth or lot of shellfish, we must be in a position to determine with accuracy not only the presence or absence of specific disease-producing pollution and also the directness with which such materials will gain access to the shellfish, but also we must be able to express in a quantitative degree the possibility of such specific pollution and the directness of its carriage to the shellfish. Unfortunately neither our systematic supervision of infectious diseases, our methods of sanitary inspection of sewerage and waste disposal systems, nor our technical methods of determining, as a routine procedure, the presence or absence of pollution in water or shellfish, permit us to make definite estimates of the possibility of specific typhoid pollution of shellfish.

To be more explicit on these points, it may be said that while the medical profession and health officers endeavor to prevent undisinfected discharges from typhoid patients and convalescents, from gaining access to sewage and thus to tidal waters, there is no doubt

that such discharges do gain access to such waters with frequency. But how frequently, it is impossible to state.

Typhoid fever is not by any means confined to the larger centers of population with sewerage systems emptying into tidal or other waters. Indeed, the reverse is true. It has been shown by Fulton, Egbert and others quite conclusively that the disease is relatively more prevalent in rural communities. Here individual systems of sewage disposal are in vogue. The greatest danger to a water supply, and by inference to oyster beds, is not, therefore, of necessity due to the presence of sewage from a large community. Most of the outbreaks of this disease due to polluted water have been caused by the improper disposal of the discharges of but one or two cases. This is likewise the case, but to a lesser extent, in the epidemics due to polluted shellfish which have already been described.

However, even a knowledge of the number of cases of typhoid fever among a population using a particular sewerage system permits only approximate estimation of the actual infectious character of the sewage in that system at its outlet. It is well recog-
843 nized that some individuals not sick with this disease harbor and distribute the germs of it in their discharges. Therefore, for this and other reasons the estimation of the amount of sewage leaving a system of disposal is not in reality an accurate index of the "disease value" or infection "possibilities" of that sewage.

Moreover, the laboratory investigations of water sewage and shellfish furnish but little better evidence as to the specific character of a pollution, for the reason that there has never been devised a practical method for the routine determination of the presence or absence of specific disease-producing germs in such materials. All that is now undertaken in such investigations is the determination of the amount of organic matter capable of being used as a bacterial food in the water or sewage, as measured by the number of bacteria present, and the presence or absence and the quantitative estimation of the common sewage bacteria, chiefly and usually only those of the bacillus coli communis type. In other words, the laboratory measures the degree of sewage pollution but not its specific disease-producing character.

The same difficulties which have made impossible for the present the routine examination of water and other liquids for the specific disease-producing bacteria, particularly the typhoid bacillus, have likewise made it most difficult to obtain conclusive results from experiments conducted with the view of showing the fate and the duration of life of the typhoid bacillus in sewage, waters of various types and in the bodies of shellfish. However, a very considerable amount of research has been conducted by bacteriologists toward the settling of the various aspects of this special problem, and the following may be considered a brief but fair general statement of the results:

It may be said that so far as available evidence goes, the living typhoid bacillus does not multiply in either fresh or sea water or oysters under natural conditions.

Whipple has concluded from a study of the literature that the duration of life of the typhoid bacillus in salt water is not unlike that in the fresh. It is generally conceded that the life of the typhoid bacillus in fresh waters of various types is not of long duration, depending upon the action of sunlight, absence of oxygen, antagonism of other bacteria and other physical agencies.

844 Savage has shown that its life in tidal mud, under various conditions, is greater than in water from the same locations, but that, at least, the vast majority of them perish in two to three weeks.

Klein, Field and others have found that typhoid bacilli in live oysters in sea water under certain conditions do not have an indefinite existence but die in considerable numbers, and cannot, in general, be found after a few weeks.

It is, of course, understood that in all such experimental work, the difficulties of isolating typhoid bacilli from fluids containing other bacteria make it possible for some, at least, of the typhoid organisms to have remained alive and to have escaped detection. It can be said also that it is generally conceded that the bacteria of the species type of the bacillus coli communis, the most common form of bacteria found in human discharges, has at least as long a duration of life under most natural conditions as the typhoid bacillus; and that as a general rule it resists the destructive forces of such agencies for a longer period.

For these and other reasons, it must be admitted that the relative numbers of B. coli and other sewage bacteria present in water, milk and other articles of food and drink, gives us indices of a comparative and relative character of the fecal pollution of those articles. While this statement is not likely to be seriously controverted, it must not be forgotten, as we have already indicated, that the degree of pollution, as measured by the relative presence of bacillus coli or coli-like organisms as determined by present methods, is not of necessity an index of the disease-producing power of the polluted article.

From what has been said, it can be properly inferred that the sanitary inspections and the laboratory investigations can give a better idea as to the directness of general sewage pollution than of its specific character, but here again such determinations only have significance as indicative of probabilities and not as certainties in so far as the production of disease is concerned.

The British Royal Sewage Commission in the report already referred to, after carefully weighing a vast mass of evidence, makes the following statement in their conclusions on this aspect of the subject:*

845 "We find it very difficult to state to what extent bacteriology is to be relied on for the purpose of distinguishing those foreshores, pits, ponds, beds or layings from which shellfish are procured, which may be considered safe from those which should be regarded as unsafe, from the point of view of public health.

* Vol. I, p. XXXVI.

"The methods at present available to the bacteriologist do not permit of his detecting, except possibly in very rare cases, the typhoid fever micro-organism either in sewage largely diluted with sea water or in shellfish; neither do they enable him to measure, in any exact manner, whether the micro-organisms which he takes as his index of danger are of recent or remote intestinal origin. Moreover, there is no constant ratio between the numbers of the organism taken as an index and the numbers of the disease-producing organism in the typhoid intestine, in the raw sewage or in the mixture of sewage and estuary water.

"Mere numbers of B. coli or any other particular micro-organism of sewage cannot, therefore, be said to have anything approaching an exact value as an indicator of the danger of disease, and we consider that before any working bacteriological standard can be applied to this problem further knowledge is necessary."

If these statements apply to the bacteriological data, how much more do they generally apply to the results obtained by the less specific methods of measurement of pollution utilized by the sanitary engineer and inspectors.

The limitations of all branches of science in these directions have been summarized by Dr. Houston, the bacteriologist of the British Commission, who has made most exhaustive studies of shellfish pollution, in the following phrase: "Neither the epidemiologist, nor the topographist, nor even the bacteriologist can assign a definite disease value to a given pollution."

It is evident, therefore, that no attempt should be made to pass judgment of condemnation or approval upon shellfish beds and their contents, from the basis of the existence or freedom from disease-producing conditions in them, for we have no method of definitely determining such conditions.

We are forced, therefore, to rely for such action as may be advisable upon the basis of the estimation of the amount and distribution of the sewage pollution of a general character in relation to
846 shellfish beds and their contents, and to oyster drinking places. Nevertheless, making such a basis for action is fraught with no little danger, for the reason that the basis is an artificial one; and on the one hand, it is entirely possible that approval may be given under it to beds, drinking places, and indirectly to oysters and shellfish, which may become the means of transmitting disease; and on the other hand, it is more than likely that beds, etc., may be condemned which are not in reality a menace to health and will not likely become so. In fact, justice to the oyster industry on the one hand, and to the public health on the other, demands that action on this basis shall not be taken except after the most careful and exhaustive investigations of an epidemiological sanitary engineering and biological character.

In order that the opportunities for error and the difficulties of setting up and maintaining such an artificial standard may not be minimized, it is but fair to state that the British Royal Sewage Commission before making their report on the subject had spent about four years in the study of the problems of the pollution of the

oyster beds of the countries of that empire, and that the scientists and medical officers of health who testified before the Commission or worked under their direction had in some cases been debating and investigating the subject for ten years. It was the opinion of the Commission and of the scientific workers that they had not yet sufficiently covered the ground to warrant the establishment of a standard of pollution sufficiently definite for the condemnation or certification of the insanitary or sanitary condition of oyster and shellfish beds and shellfish.

The Massachusetts State Board of Health likewise spent four years in the study of the pollution of Boston harbor before they undertook to prohibit the taking of shellfish from most sections of it, and even when such action was taken they did not refer to any definite standards as a basis for their decision in the matter.

For this Department to attempt to fix standards of pollution for condemnation after a few months' work, with no adequate financial support, and a field for investigation almost equal in area and importance to that covered by the British Commission investigation, would indeed be presumptive.

It can be said, however, that the results obtained by the
847 sanitary survey and the biological investigations of the laboratory, both of which must be considered in the light of preliminary studies, exhibit a very fair degree of harmony. This harmony would appear to indicate that a more satisfactory basis for drawing conclusions as to the relative pollution of a general character of the various locations might be obtained by more thorough studies which could be made if proper resources are provided.

Sanitary Survey of Shellfish Grounds.

The engineering work undertaken in the investigation comprised the collection of data and the preparation of maps to show:

I. The character, amount and points of discharge of all pollution received by streams, tidal rivers, bays and sounds which might cause contamination of shellfish.

II. The location of all leased oyster beds and the waters from which oysters and clams are taken for market.

III. The estimated yearly output of marketable and seed oysters and of clams from each district or shipping point.

IV. The general direction of tidal currents in Jamaica bay, with reference to the principal points of pollution, by a short series of float experiments, together with the determination of the tidal prism in Jamaica and Raritan bays.

The method of procedure and the work accomplished under each of the foregoing headings will be described in detail.

I. Collection of Data Regarding Pollution.

Complete data were secured by personal inspection made by inspectors from this Department as to the pollution of all streams,

tidal rivers, bays and sounds which might affect the shellfish industry carried on in waters adjoining Long Island and Staten Island comprising all oyster cultivation districts within New York State.

The data thus collected describes, it is believed, all public and private sewers and overflow pipes from cesspools discharging into such waters, and all outside privies located near the bank of streams and bays, together with other special conditions, such as the character and amount of wastes from manufacturing plants and the location of refuse dumps, which might contaminate such waters.

848 All municipalities were visited and practically a house-to-house canvas was made along the shores and streams of Long Island from College Point on the East river easterly to Orient Point, Riverhead and Montauk Point, and thence westerly to Coney Island, comprising some 400 miles of shore line; such inspection was also made along the shores of Staten Island from the Narrows westerly to Tottenville, and northerly to Linoleumville. In addition, data was obtained as to the sewage pollution from New Jersey municipalities discharged into Raritan bay, Shrewsbury river, Raritan river, Rahway river, West brook and Arthur kill.

In this work of inspection to determine pollution, the data collected included: (*a*) The location or point of discharge of all public and private sewers, cesspool overflow pipes, outside privies and sewers carrying wastes from factories; (*b*) the number of persons served by each sewer or sewer system; and (*c*) the date of construction, when available, of each sewer and sewer system.

This data was recorded in daily reports of inspectors made in duplicate on blanks numbered to correspond to numbers shown on inspector's maps. In order to be able to show graphically on maps the results of the sanitary inspection a numerical system was adopted as follows: A number was assigned to each stream, bay or locality, and the points of pollution were numbered on maps to correspond to the numbers on inspectors' reports. The character of the pollution is indicated by a decimal number affixed to the number assigned to the locality—.1 indicating a public sewer system outlet; .2 indicating a private sewer; .3 indicating an overflow pipe from a cesspool; and .4 indicating an outside privy over the water or in such a location as to pollute the water. Subnumbers indicate the number of separate cases of sewers, privies, etc., in each locality or on each stream or bay. For instance, 109.2, indicates eight private sewers discharging into the stream assigned the number 109, and 109.3, indicates eight cesspool overflow pipes discharging into the same stream. In some instances individual cases of pollution were indicated by letters, for instance, 260.2^a, and 260.2^b indicates two private sewers discharging at separate points into the same stream.

The daily reports of inspection, signed and dated by the inspector, are numbered to correspond to the numbers on the map indi-

849 cating pollution, and give further detail of such pollution.

These reports of sanitary inspection appear in this report as Appendix II. The pollution data given in the inspector's daily reports is summarized for fourteen separate oyster cultivation districts

and appears, together with the results of sanitary analysis of water and oysters, in Appendix I to this report.

The inspectors' maps, for use in the field work, were made up by mounting and folding the Atlas sheets of the United States geological survey covering the entire tidal waters of New York State, from Arthur kill to Fishers island. From these maps and from maps of the United States coast and geodetic survey tracings and prints have been made to accompany this report, and will be found in Appendix I and III.

Much valuable assistance was rendered during the investigation by health officers and other public officials of various towns and villages.

II. Location of Oyster Beds.

Maps showing the location of all oyster beds leased by the Marine Fisheries Department of the New York State Forest, Fish and Game Commission, by the various towns in Nassau and Suffolk counties, by the county of Suffolk, and by the heirs of the Smith Estate (in Great South bay) were obtained or traced from existing maps and these bed locations were transferred to one of the inspectors' maps. No maps of oyster grounds in Manhasset bay on the north side and Hempstead bay on the south side of Long Island were available, and the map of oyster beds in Great South bay, leased by the town of Islip, did not show the location of the beds in relation to the shore lines. However, in these three instances the approximate location and extent of the beds were obtained from oyster commissioners and oystermen and are shown on the maps. The location and extent of all leased oyster beds, with notes as to natural growth oyster grounds, are shown, therefore, on the maps appearing in Appendix I and III, although it was found that the use of many of the beds had been discontinued in some localities.

The oyster beds leased by the State comprise all beds in Jamaica, Raritan, East Chester and Pelham bays, and those in Long Island sound which lie outside the bays and harbors. In general, all other oyster beds in New York State are leased by the towns in which they lie, except that the beds in the Peconic bays, Gardiner's bay, and Shelter Island sound are leased by the county of Suffolk, and except that certain beds in Great South bay from Nicholas Point eastward to Bayport, included in the towns of Islip and Brookhaven, are leased by the heirs of the Smith Estate. The locations of oyster beds in Jamaica and Raritan bays were taken from prints furnished by the New York city health department made from tracings of the maps on file in the Bureau of Marine Fisheries.

The location and extent of the leased oyster beds in the fourteen oyster cultivation districts in New York State are described in detail in Appendix I of this report.

III. Statistics Showing Yearly Output of Shellfish.

The United States Bureau of Fisheries in the last published "Statistics of the Fisheries of the Middle Atlantic States" reports that in 1904 the total yield of shellfish from New York State waters was as follows:

Oysters, 3,329,332 bushels, valued at $3,780,352, of which 2,868,507 bushels were market oysters and 460,825 bushels were seed oysters.

Hard clams, 167,992 bushels, valued at $303,599.

Soft clams, 74,993 bushels valued $95,400.

Scallops, 148,799 bushels, valued at $145,646.

Skimmers or surf clams, 11,510 bushels, valued at $6,720.

Mussels, 15,910 bushels, valued at $4,590.

In the same report it is stated in relation to the oyster industry in New York State: "The increase in the value of the products (of all fisheries) from $3,894,270 in 1901 to $6,230,558 in 1904 is due principally to the extension and success of oyster culture. In 1904, 2,847,792 bushels of market oysters were taken from the private areas and only 20,805 bushels from the natural reefs, a remarkable exhibition of the development of the cultivated grounds. As regards the value of the output, New York is now the foremost American State in oyster culture. The recent growth of this industry has been especially extensive at the eastern end of Long Island. Previ-
851 ous to 1900, oysters shipped from that region were planted elsewhere before marketing but in recent years they have been permitted to remain until large enough for market. Of the market oysters credited to the private areas of the State, 378,410 bushels, worth $404,135, and of the seed oysters 46,150 bushels, worth $39,670, were taken up by vessels owned in Connecticut and elsewhere outside of New York."

The total output of market oysters for 1904 from the Middle Atlantic States—New York, New Jersey, Pennsylvania, Delaware, Maryland and Virginia, was 14,429,974 bushels as given by the Bureau of Fisheries at Washington.

In connection with the sanitary inspection, estimates were secured when possible of the probable output of market oysters, seed oysters and clams from each locality. The data thus collected appears on the inspectors' reports and is summarized for each district in Appendix I.

IV. Determination of Tidal Currents and Volumes.

But little time was available during the investigation to carry out float experiments for the purpose of determining the direction and velocity of tidal currents as relating to the distribution of sewage in waters in which oysters are grown. However, a series of float experiments was made, extending over a period of ten days, to determine the probable course followed by sewage and sewage disposal plant effluent discharged at four of the principal points at which Jamaica bay receives pollution.

It should be stated that the determination of tidal currents and velocities, if definite results are to be obtained, requires that an extended series of float experiments and calculations covering a considerable period of time should be carried on under varying conditions of tide and winds.

The points at which floats were liberated were at the Sheepshead Bay sewage disposal plant outlet near Plum Beach channel; at the point of outlet of New Lotts sewage disposal plant northeast of Canarsie; at Bergen creek which receives the effluent from the Jamaica sewage disposal plant; and at various points in Beach channel along Rockaway Beach.

From what little information could be obtained in the ten
852 days during which experiments were carried on, as to the direction and velocity of tidal currents in Jamaica bay, it would seem probable:

1. That effluent from the Sheepshead Bay sewage disposal plant, discharged at flood tide, passes into the upper reaches of Plum Beach channel northwesterly from its junction with Broad creek, and that effluent from this plant, discharged at ebb tide, passes out of Rockaway inlet only through Plum Beach channel and Dead Horse inlet.

2. That effluent discharged from the New Lotts sewage disposal plant at the beginning of ebb tide follows a course to points opposite Canarsie Landing, keeping from 100 to 1,500 feet off shore during this course, and from Canarsie Landing gradually swings out into a deeper channel east of Bergen beach reaching points from 1,000 to 2,000 feet east of Bergen beach in about three and one-half hours.

3. That effluent from the Jamaica sewage disposal plant reaching Bergen Creek during the beginning of ebb tide passes westerly of the Rockaway Beach railroad being 1,000 feet or more off shore at this point. This effluent then swings southerly into Pumpkin Patch channel and the adjacent channel to the west.

4. That sewage discharged into Beach channel during flood and during the last of the ebb tide from various points along Rockaway beach has a tendency to hug Rockaway beach shore during the corresponding flood tide. But that sewage discharged into Beach channel during the first part of the ebb, though passing along the Rockaway beach shore during the ebb, becomes disseminated across the channel during slack water and the beginning of flood tide, and is then carried back through Beach channel, or northeasterly up through the various other channels.

Tidal Volumes.

The tidal prism of Jamaica bay inside of Rockaway point and the Sheepshead bay breakwater was obtained by measuring the area of the bay on the United States coast and geodetic survey maps. The area of the bay, exclusive of marshes, is 16,690 acres. The mean range of tide is 4. feet. So that the total volume of tidal water passing in and out of the bay twice each day is, roughly, 2,900 million cubic feet.

853 Similarly the tidal prism of Raritan bay, Sandy Hook bay and that included portion of lower New York bay lying westerly from a line drawn from Sandy Hook beacon to Fort Tompkins light is, roughly, 11,500 million cubic feet, the area being 56,620 acres and the mean range of tide 4.7 feet.

Extended field work and studies are needed to determine the direction, volume and velocity of tidal currents in these and other waters of the State in which shellfish are grown and matured.

The Bacteriological Investigations of Shellfish Grounds.

These investigations consisted in the following undertakings:

1. The general survey and study of the oyster industry in the various localities in the State, and consultations with representative scientific workers in shellfish bacteriology, oysters growers, health officers, and others interested, in order to form a proper conception of the problem as a whole.

2. The inauguration of a central laboratory for the conduct of the biological researches as to relative pollution of the waters in the vicinity of oyster beds, and of oysters.

The general survey comprised visits to the oyster beds and consultations with representative oyster growers and health officers in the vicinity of Raritan, Jamaica, East Chester, Great South, Huntington and Oyster bays, and in the district comprising Peconic bay, Shelter Island sound and Gardiner's bay.

Much general and considerable detailed information regarding the oyster and clam industries was obtained, and led to decisions as to the course of the investigations finally followed.

It was ascertained that to attempt to undertake the investigation of the natural hard clam beds and their contents would be to so divide the available energies that only very unsatisfactory and incomplete results could be obtained from either the investigation of the oyster beds and oysters or that of the clam beds and clams. As the clam industry represents less than 1 per cent. of the volume of that of the oyster, it was deemed best to defer the study of the clams and their surroundings until a later period.

It appeared from the knowledge obtained during this general survey that oysters in Raritan and Jamaica bays finished spawning earlier than those in other sections of the State. In conse-
854 quence, these oysters were found to arrive at a marketable condition in advance of others. It was, therefore, believed that it would be easier to obtain samples of oysters in proper physical condition from these locations earlier in the season than from other sections. Moreover, the size and importance of the industry at these two points, and the apparent proximity of these locations to the large centers of population, led to the decision to make as extensive investigations in these two sections as the facilities and time at our disposal warranted.

It was likewise decided to undertake the examination of samples of water and oysters to be taken from other locations, selecting as far as possible such as would be most likely to show the more serious

pollutions and those which might reasonably be suspected of freedom from pollution.

The collection of samples was commenced the latter part of July and continued until October 1st.

The oyster samples were, in large part, collected through the courtesy of the various oyster producers by the sanitary chemist of the State Hygienic Laboratory, and the data regarding the locations from which they were collected and the conditions of collection are as complete as it was possible to obtain them with the facilities at hand.

The total number of samples of all kinds examined was 332. Of these, 128 were of water and 204 were of samples of oysters. In all 926 oysters were subjected to bacteriological examination.

The Bacteriological Study of Oysters and Their Surroundings.

The detailed results of these laboratory investigations in each of the fourteen oyster cultivating districts will be found in association with results of the sanitary surveys of these districts.

Descriptions of methods employed:

a. The oysters were first cleaned and a spot near the hings on the shell was sterilized by heat. With a drill sterilized by heat, a hole was drilled partly through the upper shell. The place where the hole was partly drilled was again flamed, as was the drill, and then the hole was drilled completely through the shell. This made it possible to draw off the shell water with a pipette from a point near the oyster's mouth.

855 *b.* As a test for bacilli of the B. coli type, the shell water was then inoculated into Jackson's bile media, and from the bile tubes which showed fermentation, lactose litmus agar plates were made and slants were made from typical colonies.

The results of tests for bacilli of the B. coli type shown in the tables of the Appendix are presumptive, as in only a few instances were confirmatory tests made from the agar slants.

The results that were obtained by confirmatory tests were generally positive.

The samples of water that were examined were also inoculated into Jackson's bile media. Early in the investigation it was found that bacilli of the B. coli type were so prevalent in the shell water of oysters taken from certain localities when 1 c. c. of the shell water was inoculated, that it was realized that there would be few quantitative distinctions, unless different volumes of the shell water *was* inoculated from oysters taken from a given place.

c. Afterward different volumes of the shell water were inoculated in the bile tubes; but because it was necessary to minimize the amount of work, the volumes taken of oysters from given localities were varied according to the location, and the conclusions derived from a knowledge of the locality.

In places where the sanitary survey indicated that the oysters might be more seriously polluted, 1/10 and 1/100 c. c. inoculations

were made. From four to six oysters from a given bed were usually examined.

Approximate quantitative B. coli type results were also obtained upon the samples of water from the oyster beds by inoculating different volumes in a similar manner.

On the water samples, bacterial counts were made upon standard gelatin incubated for forty-eight hours.

Comments upon the Results of the Sanitary Examinations and the Bacteriological Investigations.

In view of the statements made under sections A and B in the preliminary remarks of this report, it must be manifest that even if the investigations here reported had been carried out over a period of years and with the greatest care allowed by our present scientific methods, it would not be possible to draw conclusions as
856 to the presence or absence of disease-producing power of the oysters from the results here reported.

As has been stated, while the results of the field and the laboratory work are in close harmony, the studies can only be considered as preliminary, and as such the Department is not warranted in passing final judgment on the results for the purpose of administrative action. This does not carry with it, however, the necessity for refraining from the tabulation of the results on the basis of the relative conditions as found.

Certain workers in bacteriology have undertaken to classify the results of the examination of oysters by groups, and have referred to the results placed in certain groups as being subject to degrees of pollution.

Thus Houston* in his published article on shellfish pollution outlines six groups on the basis of his findings of bacillus coli communis in the whole oyster.

The table expressing these groups is here reproduced, and in its provisions and statments gives a tabulated conception of the whole problem of the fixation of standards.

---

* Houston. Journal of Hygiene. 1904. Vol. 4. p. 182.

† It must, of course, be definitely understood that it cannot be said that oysters of Class II or even Class I are necessarily always safe, or that oysters of Class III–VI have a definite "disease value."

No. 1. To obtain approximate results per c.c. of oyster, divide the foregoing figures by ten.

No. 2. The approximate results per c.c. of oyster have been computed and expressed in terms of volume of oyster in which B. coli is present are here inserted in brackets in Dr. Houston's table.

No. 3. This does not mean administrative, practical or legislative condemnation, but only that the evidene of pollution is sufficiently defined to merit objection from the bacteriologist's point of view.

No. 4. As regards tests (1), (2), (3) and (4), my work for the Local Government Board on the B. coli of recently voided normal human faeces shows that of 100 B. Coli, 98, 92, 98 and 92 per cent. yielded positive results in each instance to one or other test. As regards all four tests (taken in conjunction) 85 per cent. yielded positive results.

Bacteriological Grouping of Oysters.

Class.	Standard based on numerical abundance of B. coli (or non-liquefying, gas-forming coli-like microbes), in the whole contents of the oyster shell (i. e., liquor, body and interior juices of the oyster).
I.	
An oyster showing no evidence (bacteriologically) of objectionable contamination.	No B. coli.
II.	
An oyster showing appreciable, although slight, evidence (bacteriologically) of objectionable contamination.	1 B. coli per oyster No. 1. No. 2 (approximately, B. coli in 10 c. c. of oyster).
III.	
An oyster, showing definite signs (bacteriologically) of pollution and, therefore, possibly to be viewed with some degree of suspicion.	10 B. coli per oyster No. 1. No. 2 (approximately, B. coli in 1 c. c. of oyster).
857 IV.	
Stringent standard: An oyster showing such obvious signs (bacteriologically) of pollution as to be condemned on a stringent standard.	100 B. coli per oyster No. 1. No. 2 (approximately, B. coli. in 1/10 c. c. of oyster).
V.	
Lenient standard: An oyster showing such unmistakable evidence (bacteriologically) of pollution as to be condemned on the basis of results No. 3.	1,000 B. coli per oyster No. 1. No. 2 (approximately, B. coli in 1/100 c. c. of oyster).
VI.	
An oyster showing such gross evidence (bacteriologically) of contamination as to be outside the pale of recognition.	10,000 B. coli per oyster No. 1. No. 2 (approximately, B. coli in 1/100 c. c. of oyster).

In Classes with Tentative.

Numerical standard confirmed or modified according to response of the coli-like microbes in pure culture to certain well-known biological tests:

For example:
(1) Neutral-red broth test—
Greenish-yellow fluorescence (48 hours at 37° C).
(2) Lactose peptone test—
Gas and acid productions (48 hours at 37° C).
(3) Indol test—
Indol in broth culture (5 days at 37° C).
(4) Litmus milk test—
Acid clotting of milk (5 days at 37° C).

Of course, the more tests applied, the better, but the above are all known tests of value No. 4.

858 Standards for Comparative Purposes.

Provisional bacteriological conclusions confirmed or modified by topographical observations.	Provisional bacteriological and topographical conclusions confirmed or modified by epidemiological and administrative considerations.
For example: Dilution: set of the tides; prevailing winds; float experiments; time interval; distance, etc., etc.	For example: Questions of practicability; whether the contaminating material is likely to have a high or a low enteric morbific value; past epidemiological experience in circumstances broadly parallel, etc., etc.

For the purposes of comparison, we may take the work conducted under the direction of the Massachusetts State Board of Health,* which has already been referred to. As has been stated, this work was in progress for several years. The only instance of the condemnation of any location as a source for the production of shellfish by this Board is that of Boston Harbor. It is of interest, therefore, to note the results of the sanitary survey and of the examination of shellfish and water from the same, and the grounds upon which the condemnation was made.

The sanitary survey showed that approximately 170,000,000 gallons of sewage were poured into the waters of the harbor at three points daily, and that also a considerable amount was contributed at a large number of other points, but no estimates of those amounts

* 37 Annual Rept. Mass. State B. of Health, 1905. p. 16, 411-58.

were given. It should be stated that 100,000,000 gallons of the sewage is sent out to sea with the outgoing tides. Nevertheless, it is stated that the waters of the harbor are subject very generally to considerable pollution. Apparently were it not for the marked purifying action of the tides, the harbor would soon be in an intolerable condition. However, it is stated in the report that the incoming tide returns none of the previous outgoing pollution with it.

859 Regarding the laboratory examinations of the water and shellfish, the report is not specific as to the exact bacteriological methods used in the tests. In the key on the map are the statements that the results for the tests on the clams are B. coli in 1 c. c. of the shell water or in the body of the clam. No figures are shown, however, on the map, the results being indicated by + or 0 signs, indicating, respectively, the presence or absence of B. coli presumably in 1 c. c.

In the table on page 424, the results are given in terms of samples containing various sewage bacteria in either shell water or the bodies of the clams, presumably again in 1 c. c. Examining these results, we find out of 125 samples of clams examined all but twenty-nine showing the presence of either B. coli or sewage streptococcus in either the shell water or body of the clams, and in only four instances were there less than 50 per cent. of the samples from a given place showing these bacterial evidences of pollution. In only fifty-six samples out of 125 were B. coli found in the shell water of the clams. It should be stated, however, that in the work reported in other parts of this volume, there are statements leading to the conclusion that in many shellfish from the most polluted sources the B. coli were not to be found in the shell water or the body of the clams. In such locations the usual presence of streptococcus gave indication of the possible overgrowth of B. coli by the latter. As this is an experience which we did not note in our work, it is possibly due to a difference in the methods employed.

Taking all these facts into consideration, it might be arbitrarily assumed, merely for the purpose of comparison of results between the various workers, that the condemnation limit, as far as bacteriological work is concerned of the Massachusetts State Board of Health were probably not far from the presence of the B. coli type in 1 c. c. of the shell water of shellfish examined.

In the report of the bacteriological examination of oysters of Narragansett bay, conducted by Mr. C. A. Fuller for a period of three years, the author draws distinction between those containing B. coli in the shell water or body of the oysters and those which do

860 not. He speaks of the former as polluted, and the latter as not polluted. He makes no attempt at quantitative examinations of the B. coli content of either the shell water or of the various portions of the body of the oysters examined. However, it is a fair inference that quantities less than 1 c. c. must of necessity have been used by him in the tests of the intestinal and visceral content of the oysters. This might well account for his finding B. coli less often in the oysters than in the water over the oysters. In the water exam-

inations from which he drew his conclusions as to the presence or absence of pollution, his analyses were of 1 c. c. samples.

It can properly be assumed, merely for the purpose of comparison, that a maximum limit which would fairly represent the views of this worker would be the presence of B. coli in 1 c. c. of either tidal water or the shell water of the oyster.

In the report of Soper on the typhoid conditions at Lawrence, he mentions oysters showing a presumptive test for B. coli in 1 c. c. of the shell water as probably polluted, and those showing B. coli in the same way in 1/10 c. c. as definitely polluted. This latter would correspond somewhat to Houston's stringent standard.

In order to compare the results obtained by our own investigation from the various locations with each other according to these various tentative and presumptive standards of the authors quoted, the following table has been prepared.

The plus (+) indicates that if such standards as have been here attributed to the various authors were applied to the results obtained by us and were to be accepted as a basis for condemnation, the oysters from that section would come under the ban. The minus (—) sign indicates that the reverse would be the case.

It would not be proper for us to assume that the authors under consideration would be willing to assume responsibility for the application of these standards in such a manner, but the table serves well to illustrate the fact that while diversity of opinion may exist in different locations, according to variations in the presenting problems, there is not so great a general divergence from the different standards as might be expected.

861 *Tabulation of Results of Laboratory Investigations of Oysters According to the Assumed Standards of Various Investigators.*

Source of Oysters.	Massachusetts.[1]	Fuller.[2]	Houston.[3]	
			Stringent.	Lenient.
No. 1.				
Rodmans Neck	+	+	+	—
City Island	+	+	+	—
Davids Island	+	+	+	—
East Chester Bay (water only)	+	+	+	—
Island Bridge	..	..	—	—
No. 2.				
Manhasset Bay	+	+	..	..
No. 3.				
Hempstead Harbor	+	+	..	..
No. 4.				
Long Island Sound	—	—	..	..
Oyster Bay	+?	+	—?	..
Cold Spring Harbor	+?	+	..	..
No. 5.				
Huntington Harbor	+	+	+	—
Northport Bay	+	+	..	..
Huntington Bay	+	+	+	—

Source of Oysters.	Massachusetts.[1]	Fuller.[2]	Houston.[3] Stringent.	Houston.[3] Lenient.
No. 6.				
Nissequogue	+?	+	..	..
No. 7.				
Port Jefferson Harbor	—	+?	..	..
No. 9.				
Greenport Harbor	+	+	+?	..
Mattituck	+	+	..	..
Sag Harbor	+	+	—?	..
No. 11.				
Howell Point	—	+	..	..
Patchogue	+	+	+	+?
Blue Point (One sampling point)	—	—	..	..
Green Point	—	+	..	..
Nichols Point	—	+	..	..
Islip	—	+	..	..
No. 12.				
Freeport	+	+	+?	..
Milburn	+	+	—?	..
East Rockaway	+	+	..	..
No. 13.				
Old Mill Pond	..	..	—	..
Flat Lands Bay	+	+	—?	..
Big Channel	+	+	+	+
Beds near Rockaway and trestle	+	+	+	+
Ruffle Bar	+	+	—	—
Big Fishkill Channel	+	+	+	+?
Pumpkin Patch Channel	+	+	+?	—
Goosekill Creek	+	+	—	—
Raunt	+	+	—	—
Big Channel (Old Swale Marsh)	+	+	+?	—
Island Channel	+	+	—	—
No. 14.				
Raritan Bay (Great Kills and vicinity)	+	+	+?	—?
Southwest of Great Kills	+	+	+?	—

[1] Massachusetts. Assumed Massachusetts State Board of Health standard for condemnation = Bac. coli type present in 1 c. c. volumes of shell water of 50 per cent. of samples examined.

[2] Fuller. Assumed standard of C. A. Fuller, Rhode Island Investigation = B. coli present or absent in 1 c. c. volumes of tidal water or oyster shell water as indicative of the presence or absence of sewage pollution.

[3] Houston. Presumptive stringent and lenient standards of Houston. It should be stated that Houston's technic and methods of expression of results as indicated in the table quoted from his work are not those used by us, and it would not be possible to interpret our results in the terms used by him with absolute accuracy. He examined the entire contents of the oyster shells, while we examined only the shell water. Broadly speaking, however, we may reasonably assume that his stringent standard would be about equivalent to the finding of B. coli in .1 c. c. of shell water and his lenient standard to the same finding in .01 c. c. of the same.

862 It must be remembered that the above interpretations have been based upon the results of laboratory analyses alone and have not been considered in relation to the important factors involved in the "Sanitary Survey," the information and bearing of which have always been taken regularly into account by all commissions and other official bodies which have worked on this problem and have had to assume the responsibility of drawing conclusions and making recommendations for official action. In fact, when we stop to consider the indefinite nature of the evidence furnished by laboratory analyses alone, of the minute quantity of the samples of water or portion of a single oyster selected for examination, of the transitory and variable conditions represented by each sample at the time of collection, and other similar indeterminate factors which, as pointed out above, are involved in giving to such results a "disease value," it is clear to us why these commissions and official bodies have always laid special stress upon the importance of the "Sanitary Survey" and why for practical purposes, and in order to afford a basis for official action, they have given equal consideration if not precedence to the results of the "Sanitary Survey."

It is, further, quite essential that there should be no misunderstanding as to the magnitude and scope of the engineering field work properly included under the conventional designation of "Sanitary Survey," and to the difficulty of securing without more extended and full series of observations, covering a wide range of physical phenomena, the data to make this survey complete. The velocity and direction of tidal currents under variable conditions of winds; absolute and relative volume of sewage as compared with the fresh water and tidal prisms; ratios of dilution of sewage and tidal water; effects of sedimentation and scour; temperatures and densities of the sewage, fresh water and salt water in relation to stratification; the period of time elapsing during passage of sewage from sewer outfalls to oyster beds or drinking grounds; are all important factors generally embodied in the "Sanitary Survey" which have a direct or indirect bearing upon the problem, and without which an interpretation of analytical results alone would be almost meaningless.

863 It must be evident, then, that an investigation full enough to secure all of the necessary laboratory and engineering data and to satisfactorily solve all of the questions upon which can be based proper and consistent official action relative to the oyster beds and tidal waters in the vicinity of New York and Long Island is a task which it has been impossible to complete in the limited time and with the limited force of laboratory and engineering division assistants available. That a considerable and valuable amount of work has been accomplished by these two divisions along bacteriological and engineering lines, as outlined above, is true, but it is also a fact that, owing to the lack of any provision in the act, under which this investigation was required, to provide the necessary funds to carry out the investigation, it has been performed with no little sacrifice to other important work of the Department;

and that it will be necessary to continue this investigation with a more adequate force of expert assistants, and with more adequate funds, if the problem is to be solved with that definiteness and completeness assumed in the requirements of the act.

What has been accomplished so far is, however, of a permanent character, permanently recorded, and is of such nature as to form a basis of extended and more elaborate work that must inevitably be carried on in the future if rational and consistent official action is to be taken according to the provisions of the act. In the meantime, and pending this further investigation, it is manifestly fitting and desirable that no efforts be relinquished along that course which is not overshadowed by questions or uncertainty and doubt, of remedying or removing any conditions surrounding the oyster beds and waters adjacent to New York bay and Long Island, which may be a direct menace to health or by the removal of which the continued use of any particular oyster bed affected thereby may be more safely permitted.

Power is granted under section 207 of the Forest, Fish and Game Law, whereby criminal action can be taken by you against any one allowing sewage to pollute any oyster bed or beds, and the State Department of Health has also jurisdiction, under the law of 1903, over any additional pollution of the public waters which did not exist at the time the law was passed.

The policy of the State Department of Health since 1905 has been that further and unrestricted pollution of the waters of the State should cease and, insofar as the Department had the
864 power, the existing discharge of raw and ineffectively treated sewage should as rapidly as possible be prohibited.

Active work along these lines has been conducted by the State Department of Health on Long Island since the passage of the law of 1903, and its efforts will be vigorously continued, with the expectation of rapid improvement in existing conditions.

Very respectfully,

EUGENE H. PORTER,
Commissioner of Health.

865 APPENDIX I.

Summary of Pollution Statistics Reported by Sanitary Inspectors, Together with Description of Extent and Character of Shellfish Industry by Districts in New York State, with Results of Sanitary Analyses of Water and Oysters.

Oyster Cultivation Districts in New York State.

1. East Chester and Pelham district.
2. Manhasset bay.
3. Hempstead harbor.
4. Oyster bay district, including Cold Spring harbor and the sound from Matinicock Point to Lloyd Point.

5. Huntington bay and harbor and Northport bay district, including the sound off Eatons Point.
6. Smithtown bay.
7. Port Jefferson harbor district, including sound from Crane Neck Point to Mount Misery Point.
8. Along north shore of Long Island from Mt. Sinai harbor to Orient Point.
9. Peconic bay, Shelter Island sound and Gardiner's bay district.
10. Moriches and Shinnecock bay districts.
11. Great South bay, from Babylon to Patchogue.
12. Hempstead bay, from Far Rockaway to Seaford creek.
13. Jamaica bay.
14. Raritan bay.
(Maps numbered 6, 8-9-10, 13 and 14 are in Appendix III.)

1. East Chester and Pelham Bay District.

This district extends from Throgs Neck and Pelham Bay park on the west to Hart and Davids islands on the east, including the oyster grounds off Elm Point and Hewlett Point on Great Neck, and comprises the head of Long Island sound.

Formerly the greater portion of lower East Chester bay was under cultivated, but mud deposits have greatly interfered with
866 the industry so that the only areas of considerable size that are now planted lie north of Locust Point and south of Rodman Neck.

With respect to tidal conditions it may be noted that the flood tide coming up the East river apparently meets the flood coming up the sound near Throgs Neck, so that it is not likely that sewage from New York city and from the northerly sections of the borough of Queens reaches these beds.

The local pollution consists principally of the sewage discharged into Hutchinson river and canal from the city of Mt. Vernon and the villages of Pelham and Pelham Manor, and of sewage discharged into East Chester bay and the sound from City island.

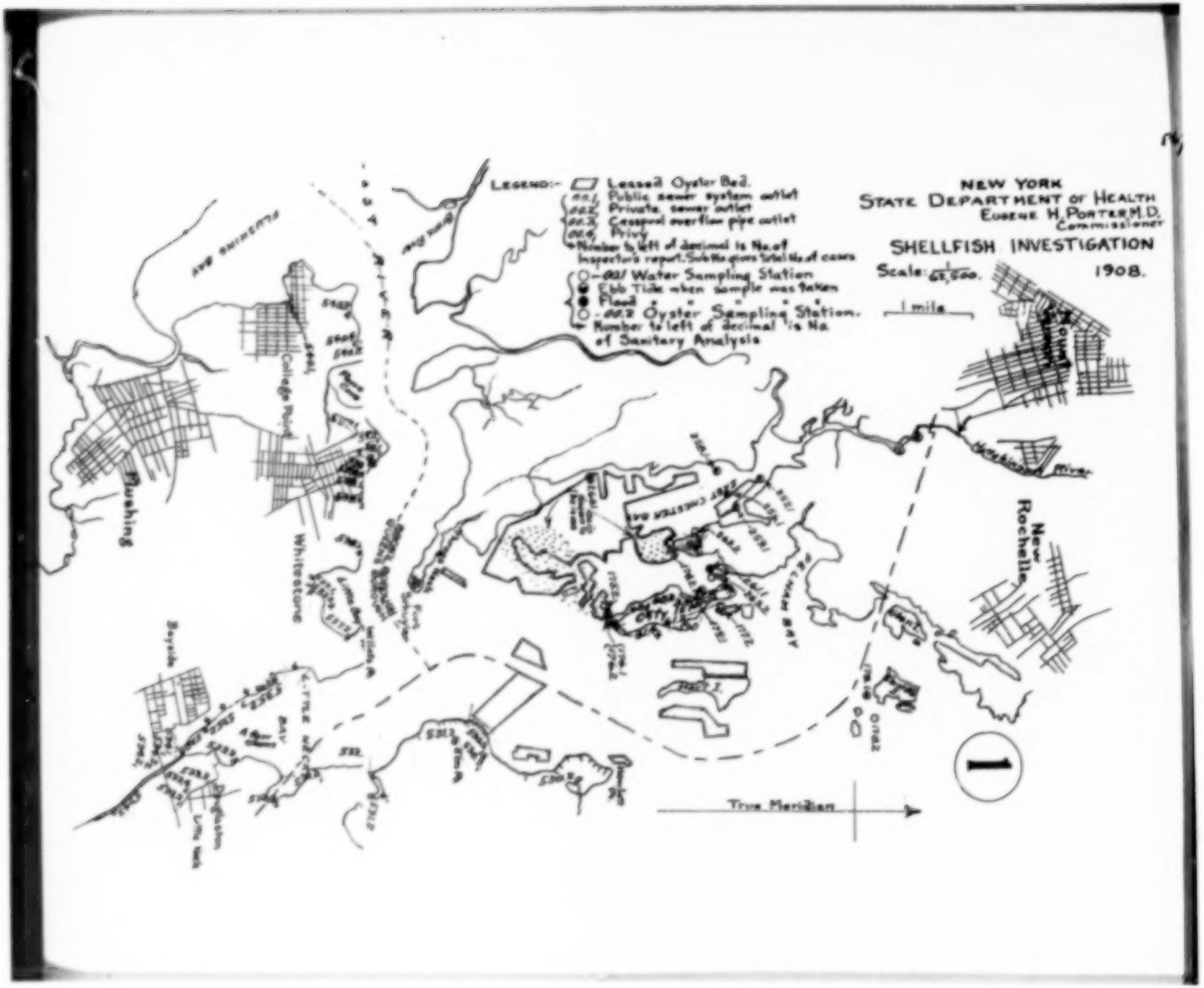
Sewer systems serving 26,000 persons discharge into Hutchinson river and canal while about 700 persons are served by short individual and party sewers on City island.

From Throgs Neck and Willets Point westerly, considerable sewage is discharged into the sound and into the East river, although, as pointed out, this does not reach the beds under ordinary tidal conditions. From Fort Schuyler on Throgs Neck and Fort Totten on Willets Point, sewage from the garrisons of several hundred men is discharged into the sound. From Whitestone, three main sewer outlets, serving a portion of a population of 3,200 in the locality, discharge into the East river.

At Whitestone, also, twenty-one private sewers discharge into the water, and nine privies were so located as to cause pollution.

At College Point sewage from a population of about 9,000 persons is discharged into the East river.

On Little Neck bay, one semi-public sewer serving thirty houses,


NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER M.D.
Commissioner
SHELLFISH INVESTIGATION
Scale: 1/62,500.
1908.
1 mile
LEGEND:-
Leased Oyster Bed.
001 Public sewer system outlet
002 Private sewer outlet
003 Cesspool overflow pipe outlet
004 Privy
Number to left of decimal is No. of Inspector's report. Sub No. gives total No. of cases
-021 Water Sampling Station
Ebb Tide when sample was taken
Flood " " "
-002 Oyster Sampling Station.
Number to left of decimal is No. of Sanitary Analysis
College Point
Whitestone
Bayside
Little Neck
Bay
Little Neck
Flushing
New Rochelle
Hutchinson River
Long Island Sound
Pelham Bay
City Island
Throgs Neck
Fort Schuyler
Davids Island
Orchard Beach
Hunters Island
Twin Islands
Glen Island
Travers Island
Pelham Manor
Pelham Heights
Pelham Park
Middle Neck
Bay
Little Neck
Bay
Manhasset
Bay
Port Washington
Sands Point
Great Neck
Manhasset
Bay
Port Washington
Sands Point
Great Neck
Flushing
Bay
Flushing
River
Flushing
Creek
Bay
Creek
Bay
Creek
Bay

twenty-two private sewers, two overflows from cesspools and eight privies contribute pollution to the waters, representing sewage discharge from 310 persons in all.

On Great Neck from Hewlett Point to Elm Point, thirty private sewers serving 150 persons discharge into the sound, together with one overflow pipe from a septic tank serving two houses.

(Here follows exhibit marked No. 1.)

867 *Oyster Cultivation District No. 1.*

East Chester and Pelham Bay.

	Sample number.	Bacteria per c. c. 20° C.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	0.001 c. c.
Rodmans Neck...	137.2	....	....	....	1+3—	0+4—	....
	262.2	....	....	....	2+3—	0+5—	....
	174.2	....	....	....	2+2—	0+4—	....
	179.1	425	0+2—	1+1—	0+2—	....	....
City Island.....	175.2	....	....	....	1+3—	1+3—	....
	176.1	30	0+2—	0+2—	0+2—	....	....
	176.2	....	....	....	2+2—	0+4—	....
	177.2	....	....	....	2+2—	0+4—	....
Davids Island ..	178.1	1,100	0+2—	0+2—	0+2—	....	....
	178.2	....	....	....	3+1—	0+4—	....
East Chester Bay	256.1	1,700	....	....	1+1—	0+2—	0+2—
	257.1	11,500	....	....	2+0—	0+2—	0+2—
	258.1	2,100	....	1+1—	1+1—	0+2—	....
	259.1	2,200	....	....	2+0—	0+2—	0+2—
	260.1	30	....	0+2—	0+2—	0+2—	....
Island Bridge....	261.1	250	....	....	0+2—	0+2—	0+2—
	263.2	....	....	....	0+5—	0+5—	....

In the tables of analytical data, the sample numbers terminating in .1 are water samples.

Those numbers terminating in .2 are numbers referring to oysters.

The + sign indicates the presence of the B. coli type.

The — sign indicates that the B. coli type was absent.

2. Manhasset Bay.

The only oyster beds under cultivation in this bay lie near Plum Point and Tom Point, about a mile west of Port Washington.

The principal points where pollution occurs are near Port Washington and at the head of the bay.

The pollution consists of discharge from private sewers, overflow from cesspools and from privies located either over the water or near the water.

In the vicinity of Port Washington and in the village, from Barker Point to the southerly limits of the village, nine private sewers and thirteen privies pollute the bay with sewage and wastes from about 200 persons, two of the sewers being hotel sewers.

From the east side of the bay south of Port Washington
868 and from the entire west side of the bay, sewage is discharged from thirty private sewers, while six overflowing cesspools, ten privies and ten households at the time of inspection were polluting the waters. Total population represented is 280.

There are several beds in the sound off shore from Manhasset Neck, from Barker Point to Mott Point. The sewage discharge along this section is very light and consists of six private sewers and two overflowing cesspools.

Oyster Cultivation District No. 2.

Manhasset Bay.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli.			
			10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Manhasset Bay ..	220.1	550	0+2—	0+2—	0+2—	....
	220.2	....	....	8+0—	....	....
	221.2	....	....	4+0—	....	....
	222.2	....	....	4+0—	....	....
Port Washington.	223.1	45,000	2+0—	0+2—	0+2—	....

3. Hempstead Harbor.

This district includes from Mott Point to Weeks Point. The oyster beds are located from Bar Beach, near Glenwood Landing, south, and lie along the harbor a little west of the center. The annual output is about 30,000 bushels. The greatest pollution received by the bay comes from the village of Glen Cove, and reaches the bay through Mosquito Cove about one mile in from the sound. Along the west side of Hempstead harbor from Mott Point to Bar Beach eight private sewers and three privies pollute the waters of the harbor.

Around both sides of the harbor south of Bar Beach, twenty private sewers and twenty-one privies were found to pollute the waters, the greatest concentration being along the ponds in the village of Roslyn. The pollution, therefore, south of Bar Beach, consists of sewage and wastes from about 200 persons, although only half of this is direct.

From Glenwood Landing, opposite Bar Beach, to Weeks Point, including the villages of Sea Cliff and Glen Cove, there are
869 four party sewers serving forty-four houses, although sixteen of these houses discharge wash water only. Also, a sewer from the Ladue leather belting works in Glen Cove takes the sewage from 500 employees.

There are also sixty-three private sewers, two overflows from cesspools, one from a boarding-house property accommodating seventy persons, and seventy-one privies which contribute to the pollution. This gives a total of 955 persons served by sewers discharging directly into the harbor along this section, overflows from cesspools receiving sewage from seventy-five persons and privies so located as to pollute the waters either directly or indirectly, used by 350 persons.

Oyster Cultivation District No. 3.

Hempstead Harbor.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Hempstead harbor	225.1	650	....	0+2—	0+2—	....
	225.2	....	....	4+0—	....	....
	224.2	....	....	4+0—	....	....
	223.2	....	....	4+0—	....	....
	227.1	500	....	0+2—	0+2—	....
	227.2	....	....	1+3—	....	....
	228.2	....	....	3+1—	....	....

4. Oyster Bay District, Including Cold Spring Harbor and Long Island Sound from Matinicock Point to Lloyd Point.

From Matinicock Point to Lloyd Point, many acres of beds are located for the whole distance along the sound, except at the entrance to Cold Spring harbor. In Oyster Bay harbor the beds lie on three sides of Center island and do not lie so close to the shore of the main land as to Center island. Beds are located entirely across Cold Spring harbor just inside of Rocky Point, and a series of beds lie close to the west side of Cold Spring harbor from Cooper's Bluff southward.

The pollution from Matinicock Point and Dosoris pond to Rocky Point at the entrance to Cold Spring harbor is very slight
870 and is caused by the discharge of seven private sewers and five overflowing cesspools distributed along a stretch of seven or eight miles.

Oyster Bay harbor receives some pollution, there being 250 persons served by forty-nine private sewers discharging into the harbor, twelve overflowing cesspools, and twenty-six privies so located as to cause direct or indirect pollution, so that at present the harbor receives pollution from about 450 persons. The greatest concentration occurs on the creek flowing through the village, there being twenty-one privies polluting this stream besides two private sewers and one overflowing cesspool. The greater portion of this pollution is permanent.

Cold Spring harbor from eighteen private sewers receives sewage from a population of 125 persons, nearly all of which is discharged at the head of the harbor. In addition there are fifteen privies so located as to pollute the waters.

There are extensive oyster beds, mostly for seed oysters located off Llyod Point, the only local pollution being from two privies.

(Here follow Exhibits marked No. 2 and No. 3.)



NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner

SHELLFISH INVESTIGATION
1908

Scale: ~~1/2,500~~

1 mile

Exhibit No. 182

Oyster Cultivation District No 4.

Oyster Bay District, Including Cold Springs and the Sound from Matinicock Point to Lloyd Point.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Long Island Sound	311.2	....	....	0+4—	....	....
	310.2	....	....	1+3—	....	....
Oyster Bay	300.2	....	....	2+2—	....	....
	313.1	1,200	....	0+2—	0+2—	....
	301.2	....	....	1+3—	....	....
	303.2	....	....	4+0—	....	....
	304.1	600	0+2—	0+2—	0+2—	....
	304.2	....	....	2+2—	....	....
	305.1	....	....	....	....	....
	305.2	....	....	4+2—	0+6—	....
	306.2	....	....	1+3—	....	....
	302.2	....	....	3+1—	....	....
	309.2	....	....	1+3—	....	....
	307.2	....	....	2+2—	....	....
	308.2	....	....	0+4—	....	....
Cold Spring Harbor	241.1	80	2+0—	2+0—	0+2—	....
	239.2	....	....	2+2—	....	....
	240.2	....	....	1+3—	....	....
	237.2	....	....	1+3—	....	....
	238.2	....	....	3+1—	....	....

871 5. Huntington Bay and Harbor and Northport Bay District, Including the Sound off Eaton Point.

The oyster beds in this district are located principally in Huntington bay and the northeasterly portion of Northport bay and in the sound northeast and northwest from Eaton Point. A few beds lie in Lloyd harbor, just inside the entrance to Huntington harbor, and a few are located at the entrance to Centerport harbor. There are approximately 200,000 bushels of marketable oysters shipped with barrels from Northport each year, principally to Norwalk and other Connecticut points. Three of the largest seed oyster dealers ship 1,500 bushels per year. No "drinking" is done in this section.

In Lloyd harbor the pollution is caused by two private sewers, serving twenty-eight persons, and a privy at the Lloyd harbor lighthouse, serving five persons.

In Huntington harbor the pollution occurs principally at the head of the harbor, and consists of discharge from twenty-two private sewers serving 220 persons in summer and from 75-100 in winter. Seven of these sewers carry sink drainage only, but the 220 persons stated are served by the remaining fifteen sewers. An 18-inch outlet from the gashouse carries the waste from the process. In addition there are two overflow pipes from cesspools, and three cases of cesspools from which seepage reaches the harbor. One of the direct overflows from a cesspool is at the yacht club. Also seven privies, used by about thirty-five persons, and two house boats directly pollute the waters.

An effort is being made to establish a sewer system in the village of Huntington, and the Huntington Association is carrying on an active campaign to free the waters of the bay and harbor from pollution.

In Huntington bay the discharge from three direct sewers carries sewage from 125 persons. A large summer hotel, with a transit population of from 500–1,000 on special days, is provided with a septic tank and subsoil irrigation system. But at the time of inspection the irrigation system was not properly operated, so that the discharge consisted of septic tank effluent. The pollution of Huntington bay is largely diminished in the fall and winter.

872 On Eaton Point only one privy was found to pollute the waters. Centerport harbor receives sewage contributed by thirty persons through three private sewers. In addition, three sink drains serving a population of 140 persons, and two overhanging privies pollute the waters. This discharge is almost entirely at the head of the harbor.

Northport bay receives sewage pollution from 1,300 persons through thirty-seven private sewers, and two public sewers. In winter this estimate is reduced somewhat, and in summer the sewage from the 525 pupils and teachers in the public school included in the estimate does not reach the bay. In addition, one cesspool, receiving sewage from ten persons in summer only, overflows into the bay, and seven overhanging privies directly pollute the water.

The greater portion of sewage discharged into Northport harbor comes from the village.

(Here follows Exhibit marked No. 4.)

4

NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner

SHELLFISH INVESTIGATION

Scale: 1/62,500. 1908

1 mile

LEGEND.

- Leased Oyster Bed
- 001 Public sewer system outlet
- 002 Private sewer outlet.
- 003 Cesspool overflow pipe outlet
- 004 Privy.

Number to left of decimal is No. of Inspector's report. Sub No. gives total No. of cases.

- ○ - 001 Water Sampling Station
- ● Ebb Tide when sample was taken
- ● Flood " " "
- ○ - 002 Oyster Sampling Station.

Number to left of decimal is No. of Sanitary Analysis.

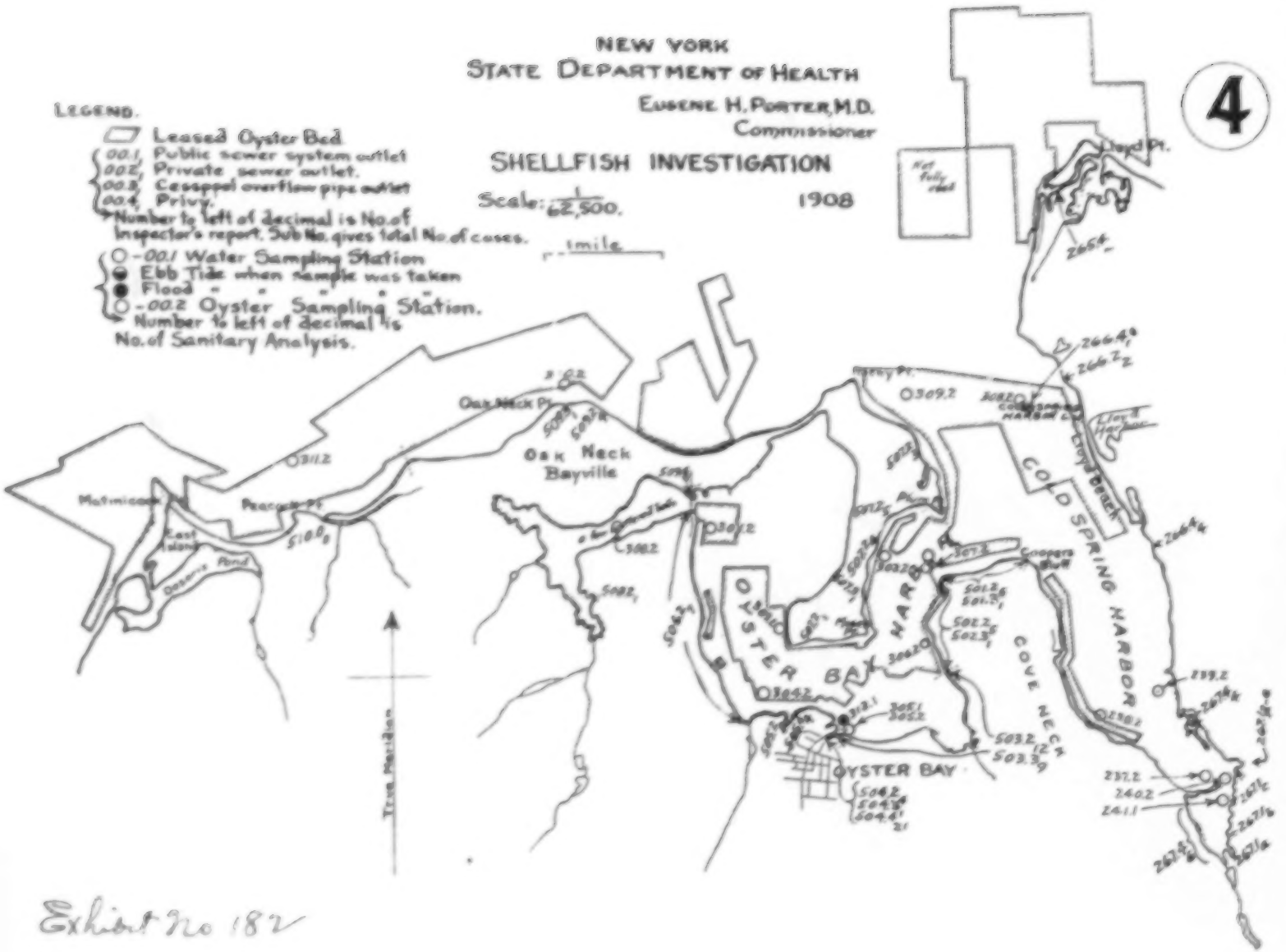


Exhibit No 182

Oyster Cultivation District No. 5.

Huntington Bay and Harbor and Northport Bay District, Including Sound off Eaton's Point.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Huntington Harbor	314.1	4,200	2+0—	2+0—	2+0—	....
	315.1	350	2+0—	2+0—	0+2—	....
	316.1	750	1+0—	2+0—	0+2—	....
	317.1	850	1+1—	0+2—	0+2—	....
	318.1	450	....	0+2—	0+2—	....
	266.1	475	1+1—	0+2—	0+2—	....
	318.2	....	....	4+0—	....	....
	266.2	....	....	....	2+4—	0+6—
Northport Bay...	246.1	7	0+1—	0+2—	0+2—	....
	246.2	....	....	1+3—	....	....
	244.1	4,000	0+2—	0+2—	0+2—	....
	244.2	....	....	4+0—	....	....
	243.1	475	0+2—	0+2—	0+2—	....
	243.2	....	....	3+1—	....	....
	247.1	27	0+2—	0+2—	0+2—	....
	247.2	....	....	4+0—	....	....
	245.1	320	0+2—	0+2—	0+2—	....
	245.2	....	....	1+3—	....	....
Huntington Bay..	267.1	210	2+0—	0+2—	0+2—	....
	267.2	....	....	6+0—	5+1—	....
	268.1	275	0+2—	0+2—	0+2—	....
	268.2	....	....	6+0—	6+0—	....
	269.1	3,500	0+2—	0+2—	0+2—	....
	269.2	....	....	1+5—	0+6—	....

873 6. Smithtown Bay.

In Smithtown bay, extensive oyster beds are located from about three-eighths of a mile to a mile off shore west of the Nissequogue river, while east of this river the beds lie close to the shore, commencing a half mile east of the river and extending for over two miles. Practically no pollution of the waters of the sound occurs except near the Nissequogue river.

At East Beach near Northport bay, one direct sewer and one privy pollute the waters.

A short distance west of the Nissequogue river the main sewer from the Kings Park Hospital discharges, carrying sewage from 4,000 inmates and attendants. The nearest beds lie, as previously mentioned, about one-half mile from this sewer and from the mouth of the Nissequogue river.

At the mouth of the Nissequogue river, a sewer from the laundry at the Kings Park Hospital, carrying laundry waste only, discharges.

The Nissequogue river is polluted by sewage from eight private sewers serving a population of seventy-five persons, by seven sink drains, by one overflow from a cesspool and by three privies, the greater amount of this pollution being discharged into the head waters of the river.

Through Porpoise channel and Stony Brook harbor, Smithtown bay receives pollution at the extreme eastern end by discharge of sewage into the above-named waters from seven sewers, serving sixty-three persons. Fourteen sink drains and eleven privies also pollute the waters of Porpoise channel and Stony Brook harbor.

The nearest oyster beds to the outlet of Porpoise channel lie three-quarter mile to the west and one-quarter mile off shore.

(Here follows Exhibit marked No. 5.)

873

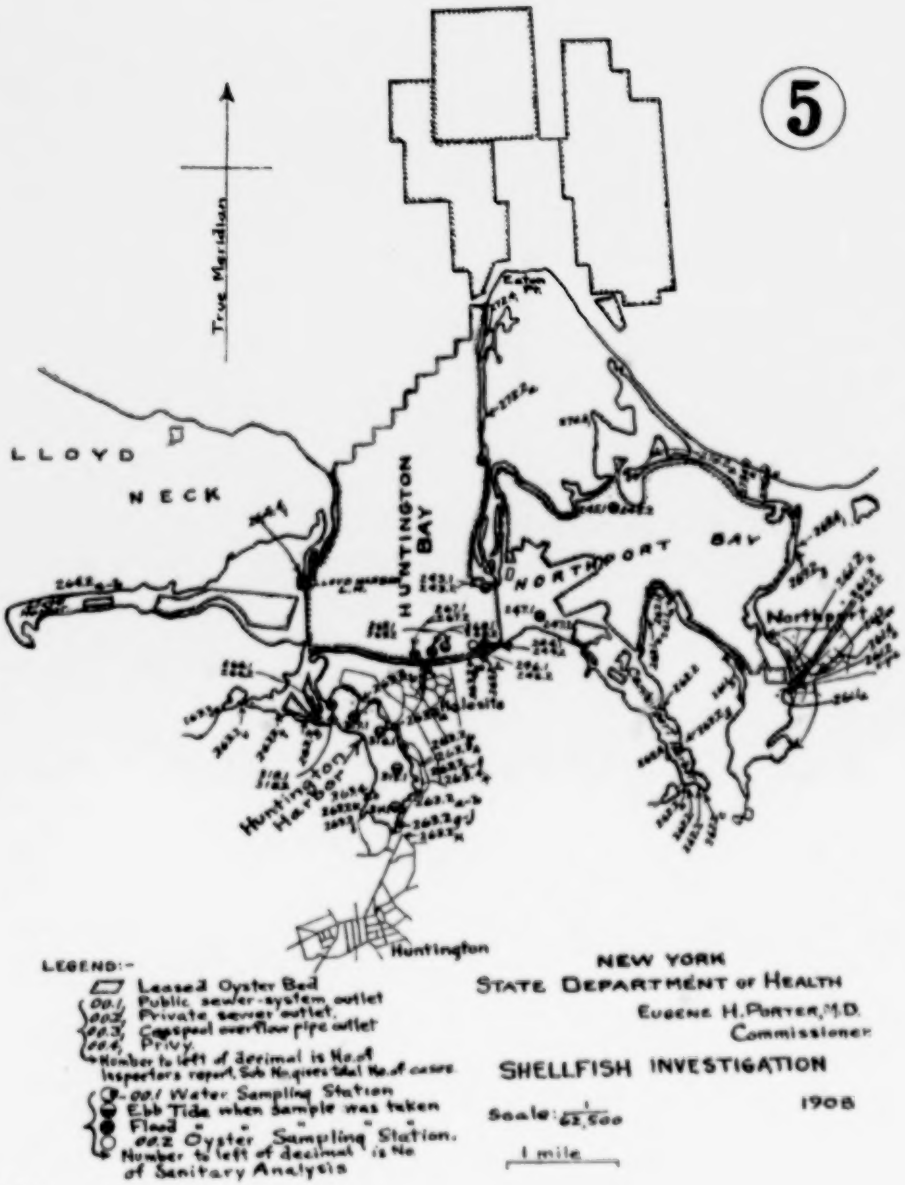
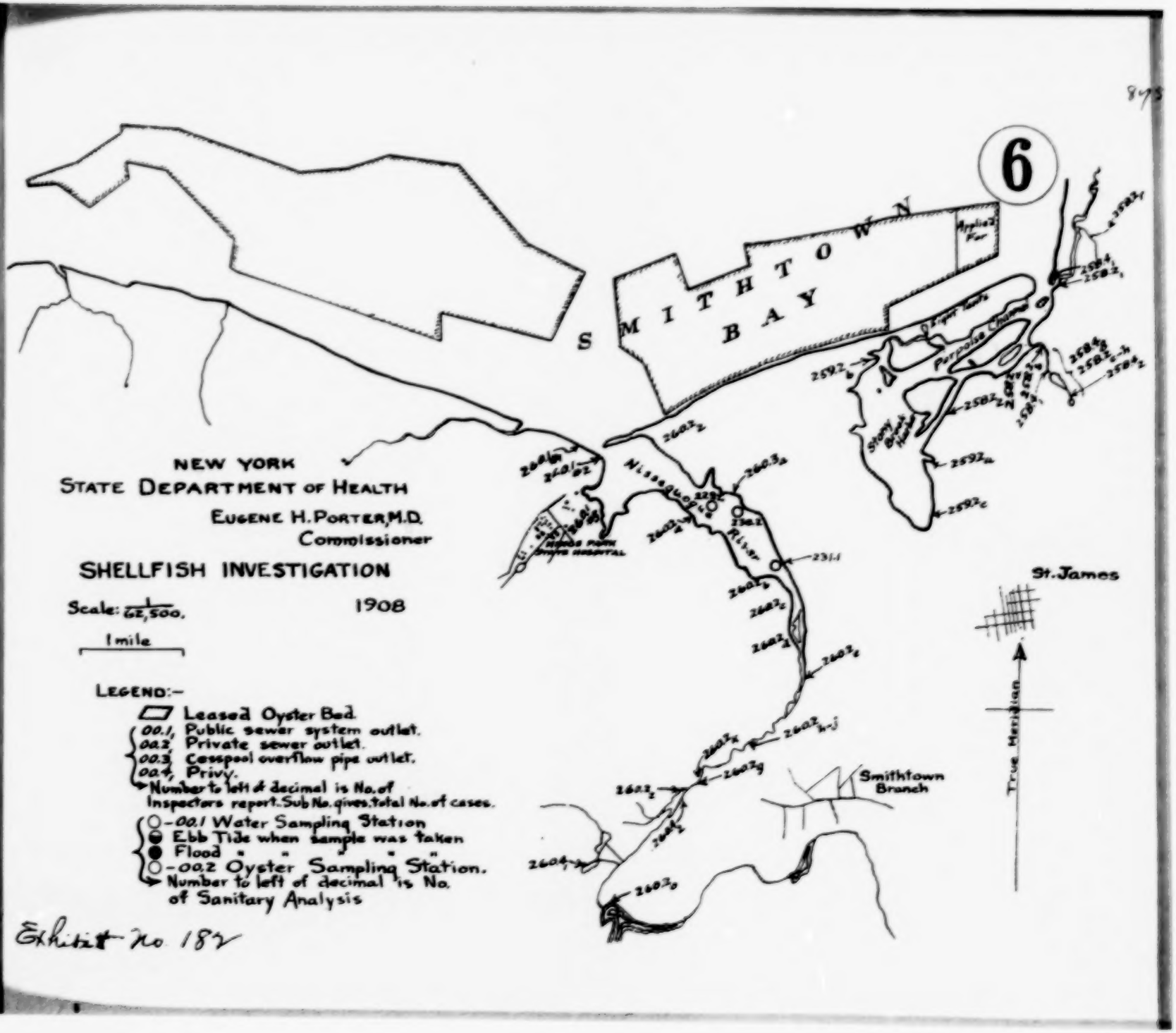
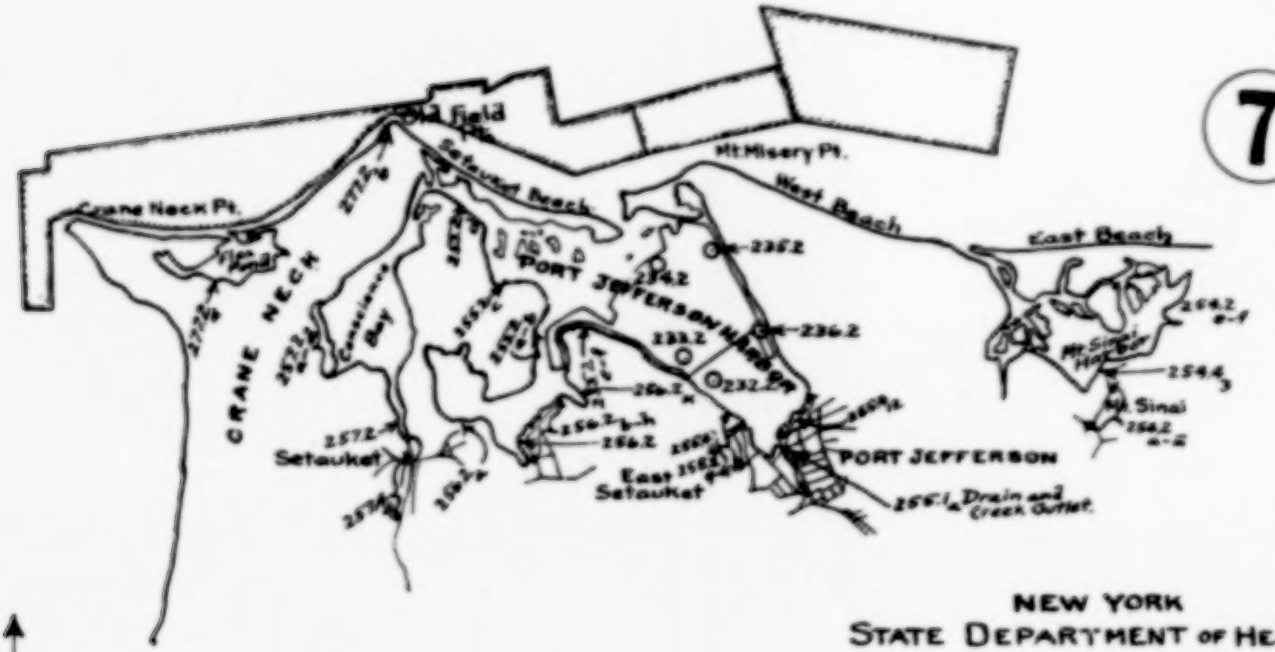


Exhibit No 182


6
NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner
SHELLFISH INVESTIGATION
Scale: 1/62,500.
1908
1 mile
LEGEND:-
Leased Oyster Bed.
00.1, Public sewer system outlet.
00.2, Private sewer outlet.
00.3, Cesspool overflow pipe outlet.
00.4, Privy.
Number to left of decimal is No. of Inspectors report. Sub No. gives total No. of cases.
-00.1 Water Sampling Station
Ebb Tide when sample was taken
Flood " " " "
-00.2 Oyster Sampling Station.
Number to left of decimal is No. of Sanitary Analysis
SMITHTOWN BAY
Smithtown Branch
St. James
True Meridian
Exhibit No. 182

7



NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner

SHELLFISH INVESTIGATION

Scale: 1/62,500 1908.

1 mile

LEGEND:-

- Leased Oyster Bed.
- 00.1 Public sewer system outlet
- 00.2 Private sewer outlet.
- 00.3 Cesspool overflow pipe outlet
- 00.4 Privy
- Number to left of decimal is No. of Inspector's report. Sub No. gives total No. of cases.
- -00.1 Water Sampling Station
- Ebb Tide when sample was taken
- Flood " " " "
- -00.2 Oyster Sampling Station.
- Number to left of decimal is No. of Sanitary Analysis

Exhibit No. 187

Oyster Cultivation District No. 6.

Smithtown Bay.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Nissequogue River	229.2	.....	.....	4+0—	2+1—	.....
	230.2	.....	.....	1+3—	0+6—	.....
	231.1	525	.....	0+2—	0+2—	.....

874 7. Port Jefferson Harbor District, Including the Sound from Crane Neck Point to Mt. Misery Point.

The oyster beds in this district lie along the sound shore and in the central portion of Port Jefferson harbor. Practically no pollution of the sound exists except one direct outlet into Flax pond serving five persons, and one sink drain, at Oldfield Point. Into Conscience bay, five direct outlets discharge, serving a population of thirty persons, while four overhanging privies pollute the bay.

The pollution of the westerly portion of Port Jefferson harbor adjoining Setauket beach and the village of East Setauket consists of sewage discharged through twelve private sewers serving seventy-five persons. There are also three sink drains which discharge into this section. Only four of these private sewers are near oyster beds.

The pollution which reaches the easterly section of Port Jefferson harbor comes from the village of Port Jefferson at the head of the harbor, one-half mile from the nearest oyster beds, and consists of sewage discharged from twenty-five direct sewers leading to the main creek, which serve as sewers for a population of 300 persons.

Of the twenty-five direct sewers, five are from hotels. In addition, twelve sink drains discharge into this creek.

Along this stream ten overhanging privies cause pollution of the waters, and two livery stables drain washings into the stream.

On the southeasterly portion of the harbor, twelve overhanging privies discharge into the water, and on the westerly side of the harbor, three direct sewers, one sink drain and four overhanging privies, all within the village, pollute the waters. The total pollution of the harbor, therefore, from Port Jefferson village is represented by the sewage and waste from 450 persons, and is fairly constant throughout the year.

875 *Oyster Cultivation District No. 7.*

Port Jefferson Harbor District, Including the Sound from Crane Neck Point to Mt. Misery Point.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Port Jefferson Harbor	234.2	.....	.....	0+4—	.....	.....
	235.2	.....	.....	1+3—	.....	.....
	233.2	.....	.....	1+3—	.....	.....
	232.2	.....	.....	0+4—	.....	.....
	236.2	.....	.....	1+3—	.....	.....

(Here follow Exhibits marked No. 6 and 7.)

8. Along North Shore of Long Island from Mt. Sinai Harbor to Orient Point.

There are only two small groups of beds in this district. One of these groups lies off Hashamomuck beach and extends from a mile to two and one-half miles east of Horton Point. The other group lies between Rocky Point and Terry Point opposite Orient harbor. Some oystering is carried on in Mattituck inlet.

Application has been made to the Marine Fisheries Bureau for oyster grounds in much of this section but such grounds are not in use, the lease having been granted subject to examination for natural growth.

Four hundred and fifty bushels of oysters per year are shipped from Mattituck.

The pollution is inconsiderable along the entire sound front.

In Mt. Sinai harbor, six sink drains discharge at various points and three overhanging privies pollute the waters at points remote from oyster beds.

Three overhanging privies pollute the waters of Wading river.

At Waterville on Mattituck inlet one drain from sinks and urinals at a hotel and one overhanging privy discharge into the inlet.

About one-half mile east of Horton Point, two cesspools receiving sewage from seventeen persons overflow into the sound, and between this point and Inlet point there is one private sewer serving nine persons.

876 At Truman Beach, one private sewer discharges one-quarter mile from the oyster beds, and at the west end of the beach, at St. Thomas summer recreation home accommodating 120 children at a time, kitchen wastes only are discharged into the sound.

Oyster Cultivation District No. 8.

Along North Shore of Long Island from Mt. Sinai Harbor to Orient Point.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli.			
			10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Mattituck	329.2	.....	.....	6+0—	.....	.....
	330.2	.....	.....	4+2—	.....	.....

9. The Peconic Bays, Shelter Island Sound and Gardiners Bay.

This district comprises the arm of the ocean included between the two easterly peninsulas of Long Island.

The beds in these waters are leased by the oyster commissioners of the county of Suffolk. Leased oyster beds occupy the greater portion of the bottoms of the bays, the only lands not leased lying under the central portions of Great Peconic bay and Little Peconic bay, nearly all of Noyack bay, the central portion of Gardiners bay and narrow strips along the shores of the bays, which are held as natural beds. Seed oysters, principally, are taken from the beds in this district.

The principal points from which these waters receive pollution are

Riverhead, Greenport, Shelter Island Heights, and the Manhanset house on Shelter Island, and Sag Harbor on the south shore of Shelter Island sound.

At Riverhead, two public sewers and one private sewer discharge sewage from a maximum of 475 persons, although this number probably falls to about 300 after the summer season. Along the Peconic river as it passes through Riverhead and the immediate vicinity, fifteen privies are so located as to pollute the stream
877 to some extent. The overflow from one cesspool reaches the waters of Flanders bay.

The oyster beds nearest Riverhead lie opposite the village of South Jamesport, four and one-half miles from the village of Riverhead.

From South Jamesport along the northwesterly shores of the Peconic bays and Shelter Island sound to the village of Greenport, very little pollution is added to the waters. Two miles east of South Jamesport one cesspool overflow pipe discharges into Great Peconic bay at a point about a mile distant from the leased beds. At New Suffolk, two cesspool overflow pipes and one sink drain discharge into the bay during the summer months.

The Standard Oyster Company at New Suffolk ship about 1,000 bushels a day during a portion of the season.

At Southold, two sink drains and one private sewer discharge into an arm of Southold bay.

Near Conkling Point a privy at a brickyard discharges on ground flooded at high tide.

At the village of Greenport, west of Fanning Point, two private sewers, serving nineteen persons, discharge into Pipes cove. From Fanning Point to the railroad dock six private sewers serving thirty persons discharge into Greenport harbor. A public sewer, with several laterals, discharges at the end of the ferry slip at the foot of Main street in the village of Greenport. The maximum number of persons served by this sewer system is 1,580, and varies somewhat since a school building, accommodating 600 pupils, is connected, as well as three hotels having a combined guest capacity of 130. Six overhanging privies pollute the waters at the shipyards along the water front.

Four party sewers, serving a population of 250–280, discharge into Stirling basin.

There is but one oyster-house in Greenport, and from 45,000 to 60,000 bushels per year are shipped from this house. "Drinking" at this house is done in private ponds of spring water.

Opposite Conkling Point and Greenport, Shelter Island sound receives sewage from Shelter Island as follows:

At Jennings Point, and south of Jennings Point, Shelter
878 Island sound receives sewage from thirteen private sewers serving sixty-five persons. These are mostly from summer cottages.

From Shelter Island heights the association sewer discharges at a point 500 feet from shore, and the maximum number of persons served by this sewer during the summer months is 1,050. This

number is largely reduced after the summer season. In addition, three private sewers, serving seventeen persons, discharge into Derring harbor.

The Manhanset House sewer, serving as a maximum 570 guests and attendants, discharges under the steamboat dock 200 feet out from shore.

On the east side of Derring harbor, the sewage from twenty-three cottages is discharged into two large cesspools having overflow pipes reaching seventy-five to one hundred feet into the harbor. This represents a discharge of sewage, or cesspool overflow, from 115 persons during the summer months.

Orient harbor receives sewage at points remote from oyster beds from three private sewers serving fifteen persons and one sewer serving fifteen persons and one sewer from a hotel having 100 guests.

A boarding-house near Long Beach bay discharges sewage into the bay.

Along the south shore of the Peconic bay, Noyack bay and Shelter Island sound very little sewage is discharged into the waters, except at Sag Harbor. One cesspool with an overflow pipe discharges into Little Peconic bay at Nyack.

At Sag Harbor, two public sewers and two private sewers discharge sewage from 715 persons into Shelter Island sound inside the breakwater. The above number includes the employees at a watch case factory and a maximum guest capacity of three hotels.

At North Haven, a private sewer discharges into the sound, and from the south shore of Shelter Island, three private sewers, serving fifteen persons, discharge into swamps and bay.

879 *Oyster Cultivation District No. 9.*

Peconic Bay, Shelter Island Sound and Gardiners Bay District.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Sag Harbor.....	333.2	.....	.....	0+6—	.....	.....
	334.2	.....	.....	6+0—	.....	.....
	335.2	.....	.....	5+1—	.....	.....
	335.1	140	0+2—	0+2—	0+2—	.....
	336.2	.....	.....	0+3—	0+6—	.....
	336.1	.....	0+2—	0+2—	0+2—	.....
	337.1	800	2+0	0+2—	0+2—	.....
Greenport Harbor	320.2	.....	.....	4+2—	.....	.....
	321.1	.....	0+2—	0+2—	0+2—	.....
	321.2	.....	.....	3+1—	1+3—	.....
	322.1	400	2+0—	2+0—	2+0—	.....
	322.2	.....	.....	3+1—	2+2—	.....
	323.1	250	0+2—	0+2—	0+2—	.....
	323.2	.....	.....	2+2—	0+4—	.....
	324.2	.....	.....	2+2—	.....	.....
	325.2	.....	.....	3+1—	.....	.....
	326.2	.....	.....	4+0—	.....	.....
	327.2	.....	.....	1+3—	.....	.....
	328.2	.....	.....	1+3—	0+4—	.....

10. Moriches and Shinnecock Bays.

No oystering on a commercial scale is done in these waters. Moriches bay is in general too shallow for oyster culture. There are no leased or cultivated grounds in Shinnecock bay, although many natural beds are found in both the east and west portions of this bay. A few natural growth oysters are found in Mecox bay, also.

Some pollution of the waters occurs around Moriches bay. One cesspool overflows into Forge river. Five cesspool overflow pipes discharge into the bay and tributary streams east of Masury Point, two of these leading from boarding-house properties or hotels. At West Cove, one direct sewer from a cottage, and one overflow pipe from a cesspool from a summer hotel having a capacity of 100 guests discharge into the water. At Hart's Cove the overflow from a cesspool at a hotel having a capacity of eighty persons discharge into the water, as well as the overflow from a cesspool at a summer school accommodating 250 persons.

Duck farms on Terrell river, Hart's Cove, and on Seatuck creek pollute the waters.

One private sewer and one cesspool overflow pipe discharge
880 into Seatuck creek. There are also duck ranches on Speonk river and at Tanner Neck. Practically no pollution of the waters occurs from this point eastward along the shores of Long Island to Montauk Point.

Oyster Cultivation District No. 10.

Moriches and Shinnecock Bay District.

No samples taken.

11. Great South Bay from Babylon to Patchogue.

The principal sections of Great South bay in which oysters are cultivated on leased lands lie from a point opposite Bay Shore for a distance of ten miles eastwardly to Bayport. A few beds are cultivated in the vicinity of Oak Island. From Nichols Point westward the beds in this district are leased by the oyster commissioners of the town of Islip. From Nichols Point eastward to Bayport, including portions of the bay which lie in the town of Islip, and portions which lie in the town of Brookhaven, the beds are leased by the heirs of the Smith estate. Easterly from this point, in the town of Brookhaven, no beds are leased by the town, but much natural growth occurs in the vicinity of Patchogue. Areas are leased by the oyster commissioners of the town of Brookhaven on the bay front at Patchogue, for the purpose of storing oysters for the winter market. The oyster grounds in Great South bay are maturing grounds and furnish the famous Blue Point oyster.

The principal shipping points are at Bay Shore, West Sayville,

Sayville and Patchogue. In a normal year over 700,000 bushels are shipped from the first three points named. From one-third to one-half of these oysters are opened at the houses.

There are no public sewer systems discharging into Great South bay. Some slight pollution of the westerly portion of the bay and its tributary streams occurs along the shore from Amityville to Bay Shore. The principal pollution along this district occurs at Babylon where a party sewer serves one hotel and six houses.

At Bay Shore, Penataquit creek, at the mouth of which are located three oyster-houses, receives pollution from four
881 private sewers, eighteen overflow pipes from cesspools and twelve privies, Bay Shore creek receives pollution from ten cesspool overflow pipes and six privies. Four cesspool pipes in each case discharge into Great cove and Champlin creek. Nichols bay and the Connetquot river receive pollution from six overflow pipes from cesspools.

At West Sayville no direct pollution occurs.

Opposite Sayville three overflowing cesspools discharge directly onto the beach or into the bay. Along the west side of Browns creek eight privies are so located on marsh land that some pollution at extremely high tide is possible. One cesspool discharges into this creek. At Browns Point four privies are located on land subject to overflow at ordinary high tide. One of these adjoins an oyster float basin and undoubtedly pollutes the water.

From the shore opposite Bayport and Blue Point, two private sewers and four cesspool overflow pipes pollute the bay.

Patchogue creek receives considerable pollution. A main sewer which drains the business portion of the village receives sewage from two hotels and about forty houses. A sewer from the lace mill discharges direct and receives sewage from 150 of the employees, while the sewage from 350 of the employees passes through cesspools. Manufacturing waste from this mill is also discharged into the creek. A sewer from a lumber yard discharges sewage from 200 employees. Two hotels discharge cesspool overflow into the bay, and one hotel, having a capacity of 200 guests, discharges sewage directly into the bay. Cesspools at the Patchogue Yacht Club overflow into the bay. In addition, four private sewers, and four overflow pipes from cesspools at individual houses contribute pollution to the bay.

Patchogue bay, therefore, is polluted either directly or indirectly by sewage from a population of nearly 1,500 persons.

The pollution of Great South bay, from Patchogue eastward, is inconsiderable.

P82 X 83

11

Babylon

Great Cove

East Islip

Great River

Connetquot River

Patchogue Bay

GREAT SOUTH BAY

FIRE ISLAND

Oak Island Beach

Fire Island Inlet

ATLANTIC OCEAN

NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner

SHELLFISH INVESTIGATION
1908

Scale 1/22,500
1 mile

LEGEND:-
- Leased Oyster Bed
- (66.) Public sewer system outlet
- (66.) Private sewer outlet
- (66.) Combined overflow pipe outlet
- (66.) Privy
- Number to left of decimal is No. of Inspectors report. Sub No. gives total No. of cases
- O—66/ Water Sampling Station
- Ebb Tide when sample was taken
- Flood " "
- O—662 Oyster Sampling Station. Number to left of decimal is No. of Sanitary Analysis

Exhibit No. 18

182 *Oyster Cultivation District No.* 11.

Great South Bay from Babylon to Patchogue.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Howell Point.....	185.2	.....	.....	1+3—	.....	.....
Patchogue	184.1	180	1+1—	0+2—	0+2—	.....
	184.2	.....	.....	.....	3+2—	.....
	186.2	.....	.....	1+2—	1+2—	.....
	188.1	700	2+0—	0+2—	0+2—	.....
	187.2	.....	.....	.....	4+0—	1+3—
	180.1	35,000	2+0—	2+0—	.....	.....
	180.2	.....	.....	.....	4+0—	4+0—
	181.2	.....	.....	3+0—	3+0—	.....
	183.1	19,500	2+0—	1+1—	0+2—	.....
	182.2	.....	.....	3+0—	1+2—	.....
Blue Point.....	189.2	.....	.....	0+4—	.....	.....
Green Point.....	190.2	.....	.....	2+2—	.....	.....
	191.2	.....	.....	1+3—	.....	.....
	200.2	.....	.....	1+3—	.....	.....
	193.2	.....	.....	1+3—	.....	.....
	192.2	.....	.....	0+4—	.....	.....
Nicholls Point....	194.2	.....	.....	2+2—	.....	.....
	195.2	.....	.....	1+3—	.....	.....
Islip	196.2	.....	.....	4+0—	.....	.....
	197.2	.....	.....	0+4—	.....	.....
	198.2	.....	.....	0+4—	.....	.....
	199.2	.....	.....	1+3—	.....	.....

(Here follows Exhibit marked No. 11.)

12. Hempstead Bay from Far Rockaway to Seaford Creek.

This district includes all the bays and creeks inside the ocean beach opposite the town of Hempstead. The oyster beds are located along the deeper channels over the greater portion of this area.

At the extreme westerly end of the district, oysters are cultivated in the upper reaches of broad channel and in the tributary leads and channels. In the easterly section, the beds are found in various channels from Cinder creek and Middle bay east to Great Island channel.

The oyster grounds in this district are maturing grounds, and the principal shipping points are at Woodmere, East Rockaway, Milburn and Freeport.

The pollution consists of discharge from private and party sewers from overflowing cesspools and from privies. No public sewer systems discharge into the waters of Hempstead bay.

East of the village of Far Rockaway, Bannister creek receives sewage from fifteen cottages through a party sewer, from two private sewers and from eight overflow pipes from cesspools, and the total population represented being 125.

883 At the westerly end of Hick's beach, nineteen cottages are served by a party sewer. Brosewere bay receives the overflow from the cesspool at the Rockaway Hunting Club, and in addition eight cottages have privies discharging into the water.

At East Rockaway, three private sewers discharge into the creek and six privies are so situated as to possibly cause pollution of the waters.

At Long Beach, a sewer serving twenty cottages or 100 persons, discharges in the summer season on to the marshes and may cause some pollution of the waters. About fifty privies along this beach are so situated that some pollution of the waters of Broad channel might result.

In addition, two privies are located along Broad channel, two along Post Lead and ten on Blackbank Hassock.

The foregoing comprises a statement of all the pollution which might affect the oyster beds in the westerly portion of Hempstead bay.

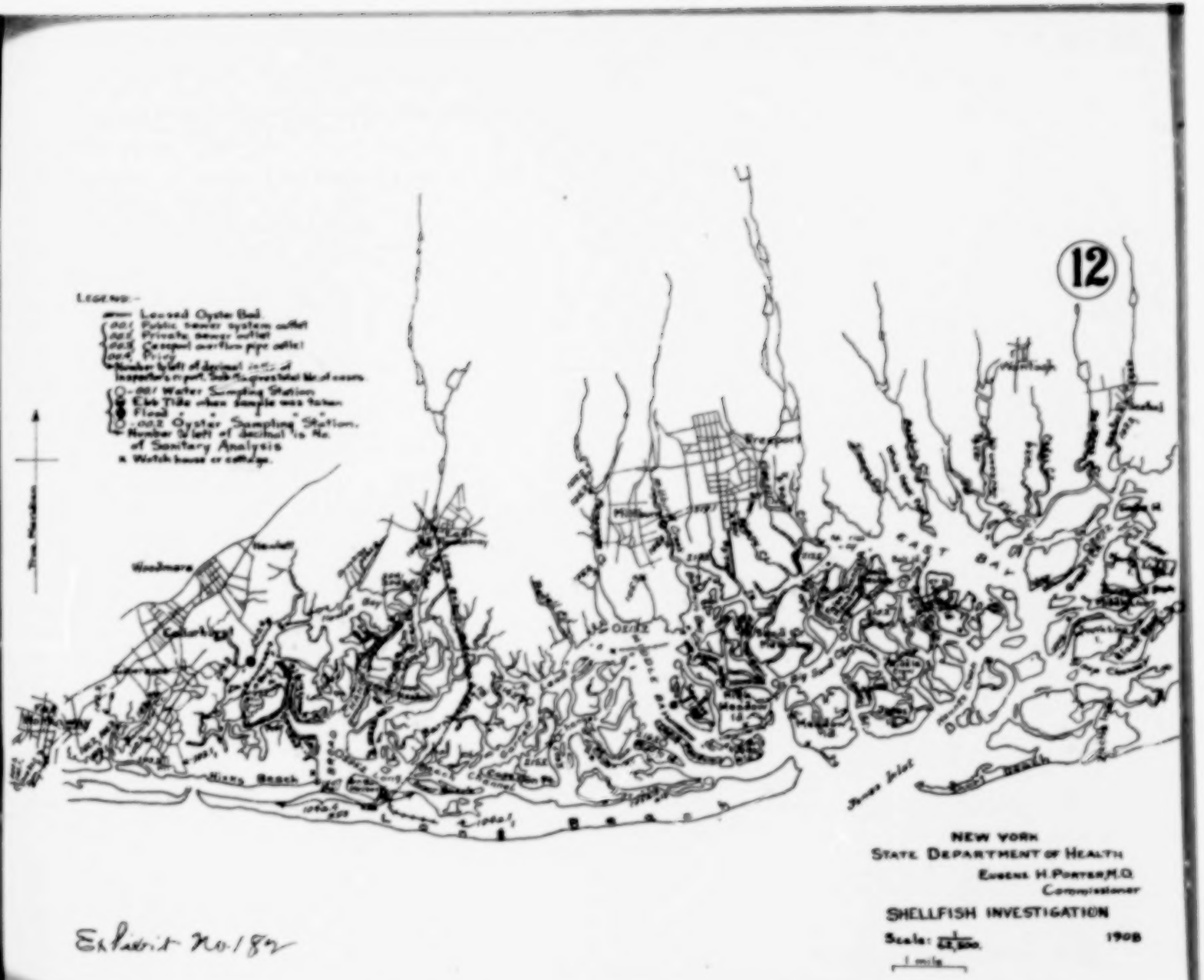
There are about twelve or fourteen oyster dealers at Woodmere dock, and shipments from this point may reach 15,000 to 20,000 bushels per year. About eight oyster-houses are located at East Rockaway. It is estimated that about 40,000 bushels per year are shipped from the grounds in Hempstead bay, west of the Long Beach railroad.

The drinking places in this section are at Hewlett creek and in two streams at East Rockaway.

At Hewlett creek, no pollution occurs in the immediate neighborhood of the drinking places.

At the main stream in East Rockaway, eight houses are located and very little pollution of the stream occurs.

A branch creek to the east of the village on which is located one oyster-house at which drinking is done is polluted by two privies



upstream from the house, one discharging directly. Also, two privies a short distance downstream pollute the waters.

The easterly section of Hempstead bay receives comparatively little pollution.

The three streams near Milburn are polluted by discharge from one private sewer, five overflow pipes from cesspools and five privies, representing a population of about fifty persons. The nearest oyster beds are a mile to the south in Middle bay.

884 At Freeport no direct sewage discharge occurs.

The only pollution of the waters is from one cesspool overflow and twelve privies on the three streams near the village. The pollution of Hempstead bay from this point eastward is also very slight. On Jackson creek are located two privies. On Cedar creek, one privy is located and Seaford creek receives sewage from one private sewer.

In addition to the pollution thus far noted, the easterly portion of Hempstead bay receives pollution from fifteen privies at Nassau-by-the-Sea near Point Lookout L. S. Station, and from privies at watchhouses and cottages located near oyster beds at the following points: One along Scow creek, one along Cinder creek, three on Alder and High Meadow islands, five adjacent to Long creek, one or two near False channel and Neds meadow, five along Broad channel, none direct, five along Great Island channel, three along South Line Island channel.

The drinking places along this section of Hempstead bay are at Milburn creek and Freeport creek and only very slight pollution from two doubtful privies in each case is possible. About 80,000 bushels of oysters per year are shipped from this section, making the total output from Hempstead bay about 120,000 bushels per year.

Oyster Cultivation District No. 12.

Hempstead Bay from Far Rockaway to Seaford Creek.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Freeport	207.2	.....	.....	0+4—	.....	.....
	208.2	.....	.....	4+0—	.....	.....
	209.2	.....	.....	0+4—	.....	.....
	210.2	.....	.....	1+3—	.....	.....
	211.2	.....	.....	4+0—	.....	.....
	217.2	.....	.....	1+3—	.....	.....
	212.2	.....	.....	3+1—	2+2—	.....
Milburn	218.2	.....	.....	3+1—	.....	.....
	219.1	9,000	2+0—	0+2—	0+2—	.....
	213.2	.....	.....	3+1—	.....	.....
	216.2	.....	.....	3+1—	.....	.....
	215.2	.....	.....	2+2—	.....	.....
	214.2	.....	.....	1+3—	.....	.....
Far Rockaway	201.1	900	2+0—	2+0—	2+0—	.....
	204.1	230	1+1—	2+0—	0+2—	.....
	204.2	.....	.....	2+2—	.....	.....
	206.2	.....	.....	4+0—	.....	.....
	203.2	.....	.....	3+1—	.....	.....
	202.2	.....	.....	3+1—	.....	.....
	205.2	.....	.....	2+2—	.....	.....

(Here follows Exhibit marked No. 12.)

885 13. Jamaica Bay (Brief Statement of Conditions).

The oyster beds in Jamaica bay, which is the largest oystering district in New York State waters, are leased by the State. Nearly every portion of the bay is occupied to some extent by oyster beds, although the industry is carried on most extensively west of the Rockaway Beach railroad. The maps accompanying this report show the location of all beds leased by the State in Jamaica bay. There are many beds shown on the maps including some near Rockaway Beach and the northeasterly end of Big channel that are not being used for oyster cultivation at the present time.

The principal shipping points on Jamaica bay are at Canarsie, Inwood and near Flatbush bay, although the greater portion of the trade is handled by schooners going directly from the beds to the New York market.

The yield of market oysters from Jamaica bay probably ranges from 500,000 to 1,000,000 bushels yearly.

The principal points of pollution are at the four sewage disposal plants at Sheepshead Bay, East New York, Jamaica and Far Rockaway, at the outlet of the Paerdegat and Kings county hospital sewers into Paedegat basin, at Bergen Beach, at Canarsie and along Rockaway Beach district. In addition to these points pollution reaches the bay from various summer cottage colonies, the principal colonies being located at Plum Beach, at Sand Bay, east of Canarsie, along Mill creek, at Ramblersville or Remsen Landing, along Bergen and Cornell creeks, and at the several stations on the bay of the Rockaway Beach railroad.

The pollution differs greatly at most points in the summer and winter seasons. The Sheepshead Bay disposal plant, using the chemical precipitation method, which the other three plants also use, receives sewage from a normal population of 2,000 in winter to a summer population of 40,000 to 50,000 on special days. The treatment is practically ineffective.

Bergen Beach is visited by from 50,000 to 60,000 persons weekly in summer, and the sewage, from an average of 8,000 persons daily, is discharged into the bay.

Paerdegat basin receives sewage from a permanent population of over 10,000 persons.

886 Canarsie is visited by an average of 16,000 persons daily in the summer season, including 30,000 on Sundays, and practically all the sewage from this population reaches the bay.

A permanent population of considerably over 50,000 persons contribute sewage to the New Lotts or East New York disposal plant. An average of 10,000,000 gallons of sewage and storm water per day is pumped at this plant, and in addition a relief by-pass is in operation from eleven o'clock a. m. until midnight. The plant is so much overtaxed, the sewage being detained for only seventeen to twenty minutes, that the treatment is practically ineffective.

At Sand Bay, 127 cottages, at Old Mill creek, 176 cottages, at Ramblersville, 220 cottages, at Bergen creek, 50 cottages, at Cornell

creek, 53 cottages, and along the line of the Rockaway Beach railroad over 200 cottages have privies which discharge into the water or onto marshes subject to tidal overflow.

The Jamaica disposal plant, effluent from which is discharged into a branch of Bergen creek, treats the sewage from about 18,000 persons out of a total population of 25,000 in Jamaica. The plant has ample capacity as a chemical precip-ation plant, although, under the best of operating conditions, a reduction of organic matter and bacteria of about 50 per cent. only is possible.

The Far Rockaway disposal plant receives sewage from a normal population of 6,500 and a summer population of 30,000. During the summer season, the plant is undoubtedly overtaxed.

The Rockaway Beach district varies greatly in population. In the winter season, from October to June, the population is about 6,000 as based on the registration. During the summer season the average daily population is from 55,000 to 60,000, and on a conservative estimate, based on the traffic figures of the railroad and steamboat lines carrying passengers to this district, the population in this district on certain days may reach as high as 125,000 to 150,000.

Twenty-nine public sewers discharge sewage from this varying population directly into Jamaica bay.

887 *Oyster Cultivation District No. 13.*

Jamaica Bay.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	0.001 c. c.
Flat Lands.....	118.1	1,000	.....	.....	1+1—	0+2—	.....
Old Mill Pond..	118.2	.....	.....	.....	0+4—	0+4—	.....
	119.1	900	.....	.....	0+2—	0+2—	.....
	119.2	.....	.....	.....	1+3—	0+4—	.....
	120.1	500	.....	.....	0+2—	0+2—	.....
	120.2	.....	.....	.....	0+4—	0+4—	.....
Flat Lands Bay	80.1	1,800	2+0—	0+2—	.....	.....	.....
	80.2	.....	.....	6+0—	.....	.....	.....
	123.2	.....	.....	.....	0+5—	.....	.....
	81.1	5,700	2+0—	0+2—	.....	.....	.....
	81.2	.....	.....	6+0—	.....	.....	.....
	124.2	.....	.....	.....	0+5—	.....	.....
	82.1	2,900	1+0—	0+2—	.....	.....	.....
	82.2	.....	.....	6+0—	.....	.....	.....
	125.2	.....	.....	.....	0+5—	.....	.....
	83.1	3,600	0+2	1+1—	.....	.....	.....
	83.2	.....	.....	6+0—	.....	.....	.....
	126.2	.....	.....	.....	0+5—	.....	.....
	84.1	5,900	2+0—	1+1—	.....	.....	.....
	84.2	.....	.....	6+0—	.....	.....	.....
	127.2	.....	.....	.....	0+5—	.....	.....
	85.1	3,500	0+2—	0+2—	.....	.....	.....
	85.2	.....	.....	6+0—	.....	.....	.....
	128.2	.....	.....	.....	0+5—	.....	.....
Big Channel....	143.2	.....	.....	0+4—	0+4—	.....	.....
	106.2	.....	.....	4+0—	3+1—	.....	.....
	91.2	.....	.....	6+0—	.....	.....	.....
	6.1	12,500	.....	3+0—	4+0—	.....	.....
	11.1	3,600	.....	3+0—	4+0—	.....	.....

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	0.001 c. c.
	107.2	.....	.....	3+1—	2+2—	.....	.....
	5.1	4,300	.....	3+0—	2+2—	.....	.....
	108.2	.....	.....	4+0—	4+0—	.....	.....
	12.1	1,900	.....	3+0—	4+0—	.....	.....
	109.2	.....	.....	1+3—	1+3—	.....	.....
	110.2	.....	.....	3+1—	2+2—	.....	.....
	3.1	15,500	.....	3+0—	4+0—	5+0—	.....
	14.1	2,200	.....	3+0—	3+0—	0+4—	.....
	112.2	.....	.....	4+0—	3+1—	.....	.....
	4.1	13,500	.....	3+0—	4+0—	.....	.....
	13.1	4,600	.....	3+0—	4+0—	.....	.....
	15.1	3,100	.....	.....	3+0—	2+2—	.....
	2.1	19,000	.....	.....	3+0—	4+0—	.....
	1.1	17,500	.....	.....	3+0—	4+0—	.....
	16.0	180,000	.....	.....	3+0—	4+0—	.....
Beds near Rockaway and Trestle	19.1	9,800	.....	1+2—	0+5—	.....	.....
	113.2	.....	.....	.....	4+0—	0+4—	.....
	167.2	.....	.....	.....	3+1—	3+1—	.....
	18.1	22,500	.....	2+1—	3+2—	.....	.....
	114.2	.....	.....	.....	4+0—	4+0—	.....
	115.2	.....	.....	.....	4+0—	3+1—	.....
	170.2	.....	.....	.....	3+1—	0+4—	.....
	116.2	.....	.....	.....	4+0—	2+2—	.....
	168.2	.....	.....	.....	3+1—	2+2—	.....
	169.2	.....	.....	.....	3+1—	0+4—	.....
	171.2	.....	.....	.....	3+1—	3+1—	.....
Ruffle Bar.....	22.1	2,000	.....	0+4—	.....	.....	.....
	74.2	.....	.....	6+0—	.....	.....	.....
	145.2	.....	.....	.....	2+2—	0+4—	.....
	75.2	.....	.....	6+0—	.....	.....	.....
	146.2	.....	.....	.....	0+4—	0+4—	.....
	87.2	.....	.....	6+0—	.....	.....	.....
	152.2	.....	.....	.....	1+3—	0+4—	.....
	88.2	.....	.....	5+0—	.....	.....	.....
	153.2	.....	.....	.....	0+4—	0+4—	.....
	41.1	700	.....	0+4—	.....	.....	.....
Big Fishkill Channel	76.2	.....	.....	5+0—	.....	.....	.....
	147.2	.....	.....	.....	3+1—	1+3—	.....
	8.1	4,200	.....	3+0—	5+0—	.....	.....
	9.1	8,600	.....	3+0—	3+0—	.....	.....
888							
Pumpkin Patch Channel	77.2	.....	.....	6+0—	.....	.....	.....
	148.2	.....	.....	.....	1+3—	0+4—	.....
	78.2	.....	.....	6+0—	.....	.....	.....
	149.2	.....	.....	.....	1+3—	0+4—	.....
Goosekill Creek.	21.1	18,500	.....	1+2—	0+5—	.....	.....
	79.2	.....	.....	5+1—	.....	.....	.....
	150.2	.....	.....	.....	0+4—	0+4—	.....
The Raunt.....	86.2	.....	.....	5+0—	.....	.....	.....
	151.2	.....	.....	.....	0+4—	0+4—	.....
	172.2	.....	.....	.....	3+1—	0+4—	.....
Big Channel (Old Swale Marsh)	89.2	.....	.....	5+0—	.....	.....	.....
	144.2	.....	.....	.....	1+3—	0+4—	.....
Island Channel.	7.1	44,000	.....	3+0—	4+0—	.....	.....
	90.2	.....	.....	4+1—	.....	.....	.....
	154.2	.....	.....	.....	0+4—	0+4—	.....

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.	0.001 c. c.
Tabulation of all analytical results of Jamaica Bay water samples	1.1	17,000	.....	.....	3+0—	4+0—	.....
	2.1	.....	.....	.....	3+0—	4+0—	.....
	3.1	15,500	.....	3+0—	4+0—	5+0—	.....
	4.1	13,500	.....	3+0—	4+0—	.....	.....
	5.1	4,300	.....	3+0—	2+2—	.....	.....
	6.1	12,500	.....	3+0—	4+0—	.....	.....
	7.1	44,000	.....	3+0—	4+0—	.....	.....
	8.1	4,200	.....	3+0—	5+0—	.....	.....
	9.1	8,600	.....	3+0—	3+1—	.....	.....
	10.1	56,000	.....	3+0—	4+0—	.....	.....
	11.1	3,600	.....	3+0—	4+0—	.....	.....
	12.1	1,900	.....	3+0—	4+0—	.....	.....
	13.1	4,600	.....	3+0—	4+0—	.....	.....
	14.1	2,200	.....	3+0—	3+0—	0+4—	.....
	15.1	3,100	.....	.....	3+0—	2+2—	.....
	16.1	180,000	.....	.....	3+0—	4+0—	.....
	17.1	24,500	.....	3+0—	1+3—	.....	.....
	18.1	22,500	.....	2+1—	3+2—	.....	.....
	19.1	9,800	.....	1+2—	0+5—	.....	.....
	20.1	5,000	.....	0+3—	0+5—	.....	.....
	21.1	15,500	.....	1+2—	0+5—	.....	.....
	22.1	2,000	.....	0+4—	.....	.....	.....
	23.1	50	.....	0+4—	.....	.....	.....
	24.1	1,900	.....	0+4—	.....	.....	.....
	25.1	100	.....	0+4—	.....	.....	.....
	26.1	50	.....	0+4—	.....	.....	.....
	27.1	1,500	.....	0+4—	.....	.....	.....
	28.1	7,600	.....	.....	.....	.....	.....
	29.1	4,200	.....	.....	2+1—	1+2—	.....
	30.1	1,800	.....	.....	2+3—	.....	.....
	31.1	7,200	.....	3+1—	.....	.....	.....
	32.1	500	.....	1+3—	.....	.....	.....
	33.1	35,000	.....	0+4—	.....	.....	.....
	34.1	100	.....	0+4—	.....	.....	.....
	35.1	3,900	.....	0+4—	.....	.....	.....
	36.1	1,100	.....	0+4—	.....	.....	.....
	37.1	1,100	.....	1+3—	.....	.....	.....
	38.1	1,100	.....	1+3—	.....	.....	.....
	39.1	5,200	.....	1+3—	.....	.....	.....
	40.1	250	.....	1+3—	.....	.....	.....
	41.1	700	.....	0+4—	.....	.....	.....
	111.1	49,000	.....	.....	0+2—	2+0—	1+1—
Shipping Points.	252.1	1,700	2+0—	0+2—	0+2—	.....	.....
Flat Lands	253.1	850	1+1—	1+1—	0+2—	.....	.....
Indian Creek..	254.1	1,000	2+0—	2+0—	.....	.....	.....
	255.1	1,500	2+0—	2+0—	4+0—	.....	.....

889 14. Raritan Bay (Brief Statement of Conditions).

Oyster grounds in Raritan bay are leased by the State. The beds are principally located from Great Kills west to Tottenville and reach nearluy half across the bay. West of Seguine Point, it is stated, the beds are used as propagating ground and no oysters are taken to be marketed from these beds.

The annual output from beds in Raritan bay, is estimated to be from 450,000 to 500,000 bushels and is sold principally in the New York market.

It is generally stated that the ebb tide coming out of the Narrows and swinging toward Raritan bay meets the ebb from Raritan bay at points to the northeast of Elm Tree beacon, so that the sewage discharged from New York city does not under ordinary conditions pass over the oyster grounds in Raritan bay during ebb tide.

Briefly, the sewage pollution of Raritan bay is as follows:

At Tottenville a population of 2,000 is served by a public sewer system having four outlets into Arthur Kill and Raritan bay.

From Ward Point to Red Bank, nine private sewers and one privy pollute the waters.

At Red Bank, a Catholic mission with 2,000 inmates discharges sewage directly into the bay.

At Seguine Point, a dental goods manufacturing company, employing 600 hands, discharges all sewage directly into the bay.

There are also three private sewers serving ten houses, and two privies on Princess bay and Lemon creek which pollute the waters directly.

East of Seguine Point, a large hotel with a capacity of 200 has practically a direct sewer to the bay. Three private sewers and one cesspool overflow also pollute the waters of the bay near Latourette pond. A short distance west of Great Kills, three private sewers discharge into the bay. At Great Kills one hotel discharges into a small stream and one discharges direct. Three other private sewers and two privies pollute the waters of Great Kills.

West of Midland Beach, a hospital with 300 inmates and attendants discharges sewage directly into the bay as well as a hotel with a capacity of fifty.

890 At Midland Beach, all the sewage is discharged into trenches in the meadows just back of the resort. Three hotels and a number of cottages are connected to the main sewer. This is a large summer resort and undoubtedly some of the sewage would reach the bay.

At South Beach, sewage from a summer resort visited by 1,000 persons a week is discharged directly into the bay.

Pollution Reaching Raritan Bay from New Jersey Municipalities.

The Raritan river in New Jersey receives considerable sewage pollution, the description of which follows:

At its mouth, approximately one-third of the sewage from 27,000 persons at Perth Amboy is discharged into the Raritan, and the rest into Arthur Kill. South river, a tributary of the Raritan, receives pollution from sixty-five private houses.

New Brunswick, population 23,000, discharges sewage direct but is under notice from the New Jersey State Board of Health to cease polluting the river by July, 1911.

Highland Park, population 714, discharges direct but will be required to treat sewage by July, 1911.

Bound Brook, population 4,000, and New Bound Brook, population 1,000, both discharge sewage direct, but are under orders to cease such discharge by July, 1911.

Somerville, population 5,000, discharges directly, but is to treat sewage by July 1, 1911.

Raritan, population 3,500, discharges directly.

Flemington has a septic tank and sand filters and takes water at Flemington Junction with no filtration. No considerable pollution occurs on Millstone river.

Green brook, a tributary stream to Bound brook and the Raritan, receives sewage directly from Lincoln, population 300.

At Plainfield, septic tank and secondary contact bed treatment are in use.

The Rahway river, discharging into Arthur Kill about eight miles from Raritan bay, receives sewage from Rahway, population 8,650, and Cranford, population 3,600. Both these boroughs must cease polluting the river by November 11, 1911.

891 Below Rahway, the State reformatory with 1,000 inmates discharges sewage into a septic tank and the effluent after passing over mud flats reaches the Rahway river. Plans to install sand filters are under way.

The Orange joint trunk sewer discharging into Arthur Kil. serves a population of 25,000 to 30,000, and Elizabeth, population 60,000, discharges most of its sewage into Arthur Kill.

Roselle has population of 1,300 connected with sewage discharging into Morse creek, a tributary of Arthur Kill.

The town of Linden has twelve private sewers discharging into West brook.

The Shrewsbury river receives pollution by direct sewage discharge as follows: Sea Bright, population 1,160, has 200 private sewers, some hotel sewers and some joint or party sewers.

Red Bank, population 6,260, has septic tank and filters.

Atlantic Highlands, population 1,480 in winter and 2,000 in summer, discharges sewage direct into Raritan bay, but is to build septic tank by June 1, 1909.

The Waterwitch Club, population 1,000 in summer, have septic tank completed in August, 1908, and sand filters were to be installed during the fall of 1908.

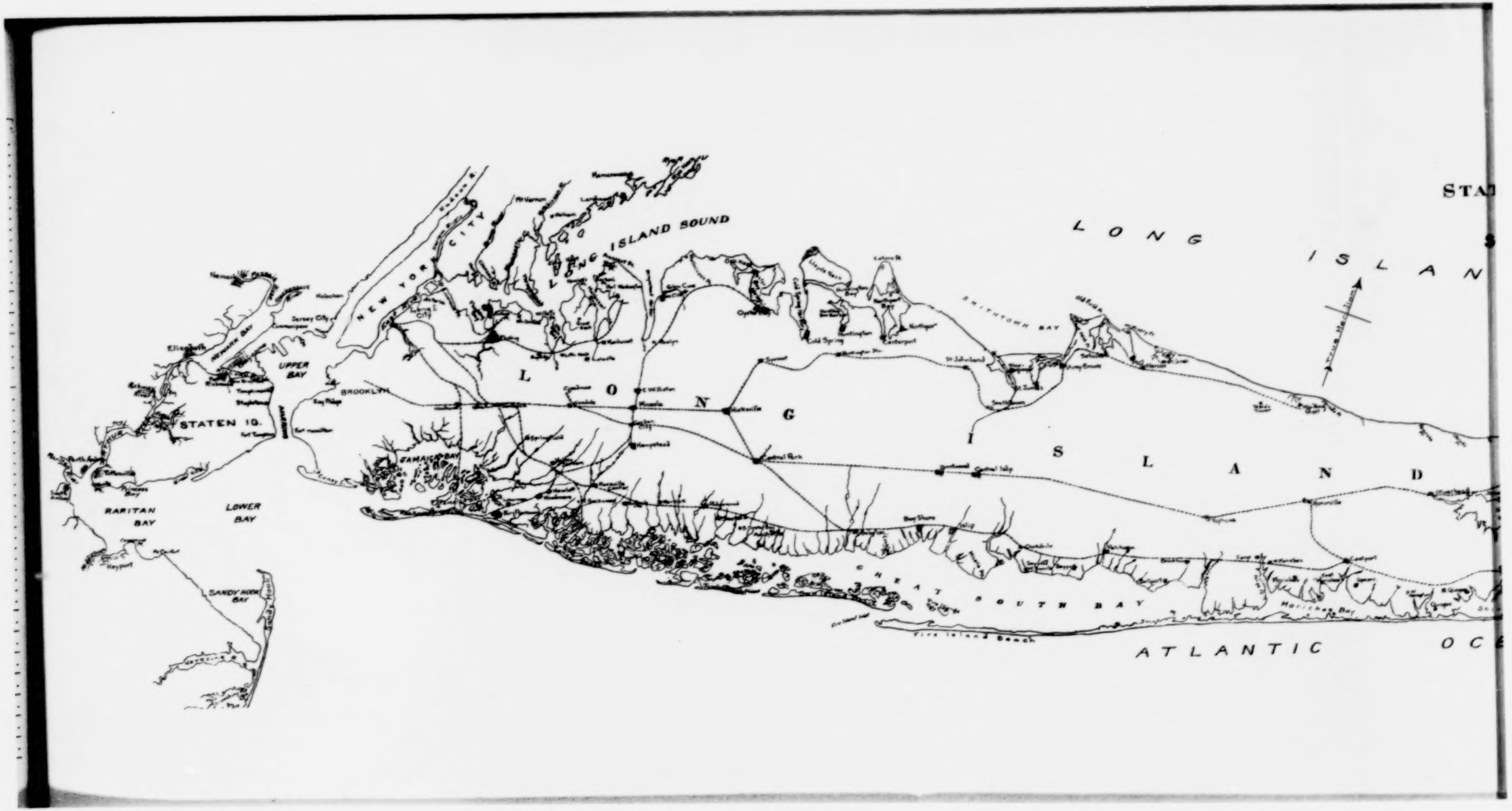
892 *Oyster Cultivation District No. 14.*

Raritan Bay.

	Sample number.	Bacteria per c. c.	Presumptive B. Coli.			
			10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
Raritan Bay Water	42.1	100	.....	0+2—	0+2—	0+2—
	43.1	1,100	.....	0+2—	0+2—	0+2—
	44.1	50	.....	0+2—	0+2—	0+2—
	45.1	400	.....	0+2—	0+2—	0+2—
	46.1	7,400	1+1—	0+2—	0+2—	.....
	47.1	.....	1+1—	0+2—	0+2—	.....
	48.1	1,100	2+0—	0+2—	0+2—	.....
	49.1	700	1+1—	1+1—	0+2—	.....
	50.1	200	0+2—	1+1—	0+2—	.....
	51.1	4,000	0+2—	0+2—	0+2—	.....
	52.1	2,500	2+0—	0+2—	0+2—	.....

	Sample number.	Bacteria per c. c.	Presumptive B. Coli. 10 c. c.	1 c. c.	0.1 c. c.	0.01 c. c.
	53.1	2,100	1+0—	0+2—	0+2—	.....
	54.1	1,700	0+1—	0+2—	0+2—	.....
	55.1	4,000	.....	0+2—	0+2—	.....
	56.1	9,100	.....	0+2—	1+1—	.....
	57.1	3,600	.....	0+2—	0+2—	.....
	58.1	2,400	.....	1+1—	0+2—	.....
	59.1	1,100	.....	2+0—	0+2—	.....
	60.1	3,600	.....	1+1—	0+2—	.....
	61.1	1,400	.....	1+1—	0+2—	.....
	67.1	2,000	2+0—	0+2—	0+2—	.....
	69.1	210	0+2—	2+0—	0+2—	.....
	95.1	240	.....	1+1—	0+2—	.....
	99.1	130	.....	0+2—	0+2—	.....
	62.2	.....	.....	4+2—	.....	.....
	161.2	.....	.....	.....	1+3—	0+4—
	63.2	.....	.....	5+1—	.....	.....
	162.2	.....	.....	.....	4+0—	3+1—
	64.2	.....	.....	6+0—	.....	.....
	155.2	.....	.....	.....	2+2—	0+4—
	65.2	.....	.....	6+0—	.....	.....
	141.2	.....	.....	.....	0+5—	.....
	66.2	.....	.....	6+0—	.....	.....
Great Kills and vicinity	156.2	.....	.....	0+4—	0+4—	0+4—
	72.2	.....	.....	3+3—	.....	.....
	140.2	.....	.....	.....	0+5—	.....
	73.2	.....	.....	5+1—	.....	.....
	142.2	.....	.....	.....	2+3—	.....
	92.2	.....	.....	4+1—	1+4—	.....
	131.2	.....	.....	.....	2+3—	.....
	93.2	.....	.....	4+1—	.....	.....
	132.2	.....	.....	.....	1+4—	.....
	94.2	.....	.....	3+2—	1+1—	.....
	133.2	.....	.....	.....	2+3—	.....
	134.2	.....	.....	.....	0+5—	.....
	96.2	.....	.....	5+0—	.....	.....
	135.2	.....	.....	.....	2+0—	.....
	97.2	.....	.....	4+1—	.....	.....
	136.2	.....	.....	.....	0+5—	.....
	98.2	.....	.....	5+0—	.....	.....
	137.2	.....	.....	.....	3+2—	.....
	99.2	.....	.....	2+3—	.....	.....
	138.2	.....	.....	.....	1+4—	.....
	100.2	.....	.....	5+0—	.....	.....
	159.2	.....	.....	.....	0+4—	0+4—
	101.2	.....	.....	5+0—	.....	.....
	160.2	.....	.....	.....	0+4—	0+4—
	70.2	.....	.....	3+1—	0+2—	.....
	158.2	.....	.....	.....	0+4—	0+4—
	68.2	.....	.....	6+0—	.....	.....
	157.2	.....	.....	.....	1+3—	0+4—
	71.2	.....	.....	5+0—	1+1—	.....
	163.2	.....	.....	.....	0+4—	0+4—
	102.2	.....	.....	5+0—	.....	.....
	164.2	.....	.....	.....	0+4—	0+4—
	103.2	.....	.....	5+0—	2+0—	.....
	165.2	.....	.....	.....	2+2—	0+4—
	104.2	.....	.....	5+0—	.....	.....
	166.2	.....	.....	.....	4+0—	1+3—

(Here follow exhibits marked No. 0, Nos. 8, 9, 10, and No. 13.)


LONG ISLAND SOUND
NEW YORK CITY
LONG ISLAND
STATEN IS.
BROOKLYN
UPPER BAY
LOWER BAY
RARITAN BAY
SANDY HOOK BAY
Sandy Hook
JAMAICA BAY
SMITHTOWN BAY
GREAT SOUTH BAY
Fire Island Beach
ATLANTIC OCE

8924

NEW YORK
STATE DEPARTMENT OF HEALTH
EUGENE H. PORTER, M.D.
Commissioner

SHELLFISH INVESTIGATION
1908

Scale: 1/250,000

0

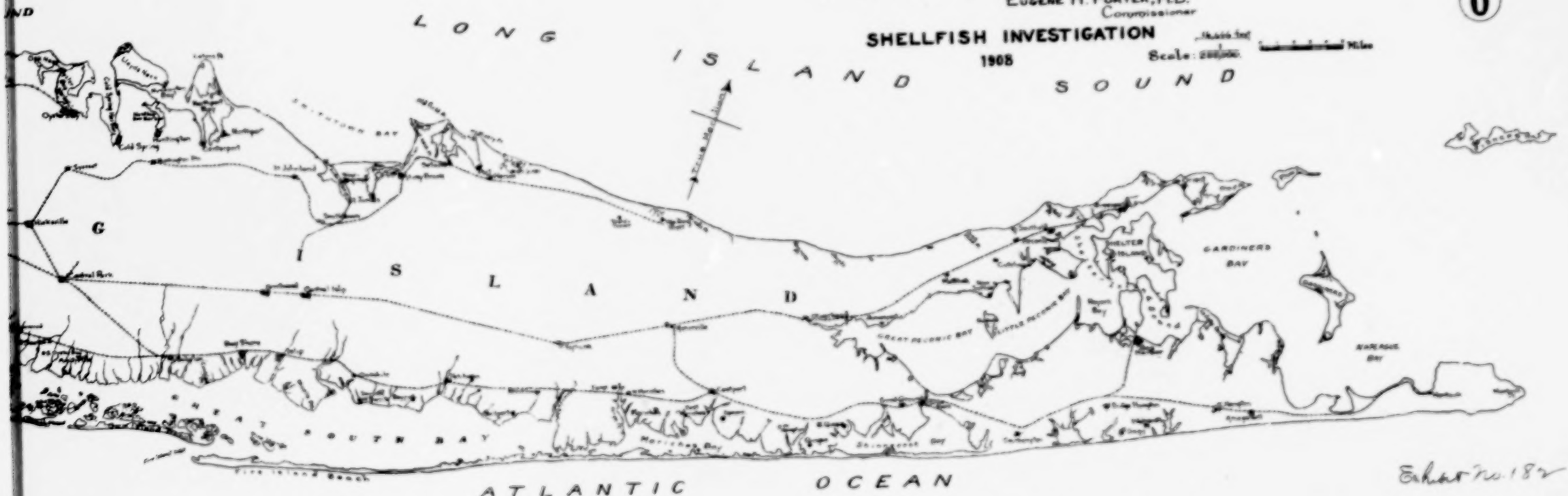


Chart No. 182

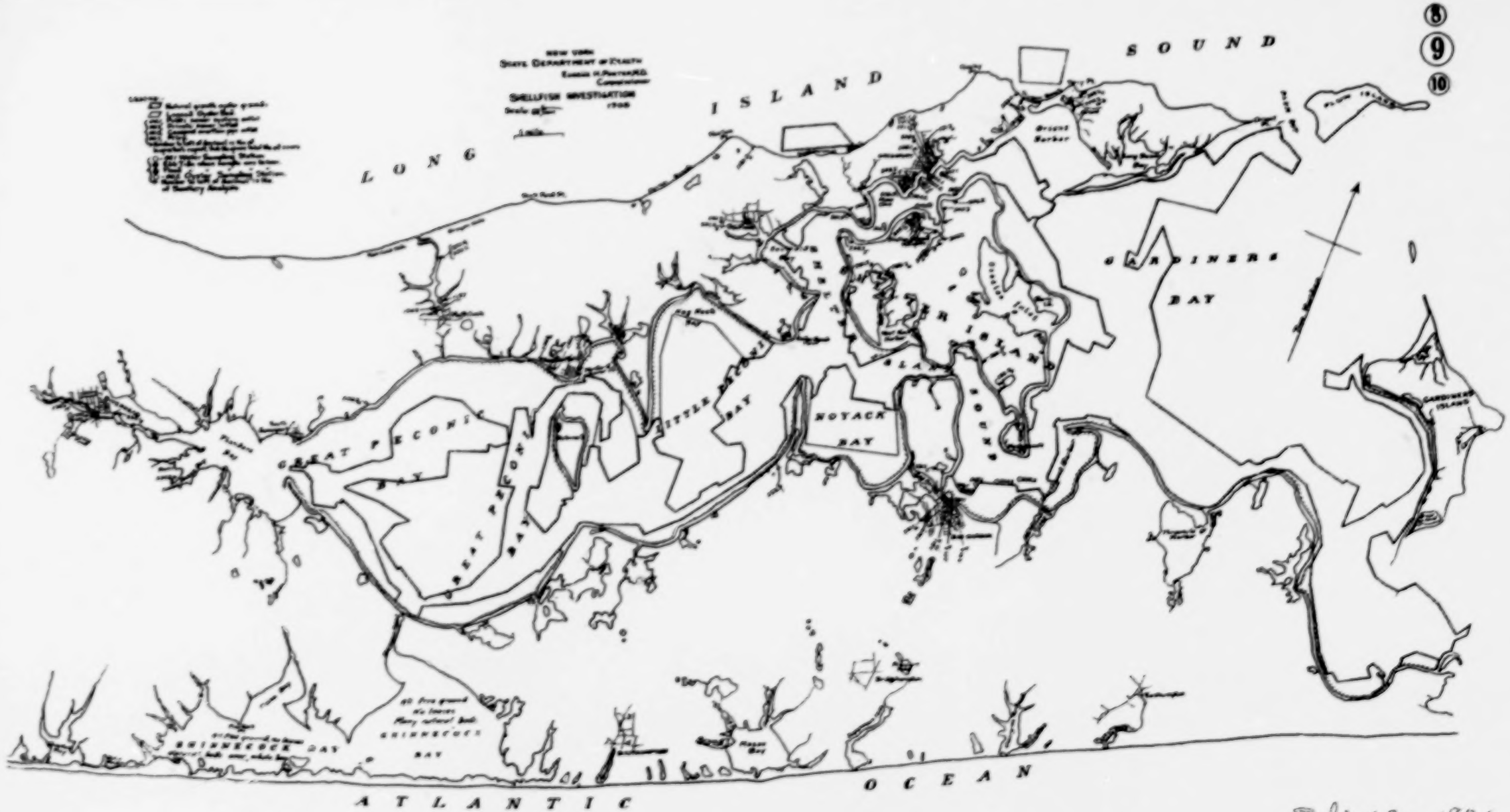


Exhibit No 182

1 COMPLAINANTS' EXHIBIT No. 183. James D. Maher, Commissioner.

Joseph A. Deghuée, Ph. D.
Frederic D. Bell.
Harry E. Bramley.
Herbert D. Pease, M. D.

Lederle Laboratories,
39-41 West 38th Street, New York City.

No. —.

Directions for Collecting Oysters for Bacteriological Examinations.

Select twelve (12) or more oysters, preferably three or more years old, from each bed to be tested.

Pack the twelve (12) or more oysters from each bed in the shell in a paper ice-cream or bulk oyster box.

Mark each box with the bed number.

Fill out information blank, put in envelope and attach to box containing corresponding bed sample.

Pack paper boxes containing oysters in wooden box with excelsior.

Ship samples by express as soon as possible after collection. Do not lay down or float oysters before shipment or allow them to come in contact with dirt or other material.

If the sample is to arrive at the laboratory within thirty-six (36) hours during the winter season no ice is necessary. Ice is not necessary if sample is to arrive within twenty-four (24) hours at any season.

Directions for Collecting Water for Bacteriological Examinations.

The utmost care must be taken that the fingers do not come in immediate contact with the stopper or neck of the bottle. Loosen the edges of the tinfoil from the neck of the bottle. Grasp the stopper, still covered by the tinfoil, in the left hand and the bottle below the neck with the right and gently remove the stopper. If the latter sticks it can be loosened by a slight tap on the edge of the stopper.

Under no condition should the part of the stopper not covered with tinfoil, be allowed to come in contact with anything.

Plunge the bottle rapidly below the surface to avoid surface scum; get it completely full and withdraw quickly.

If the sample is taken from a shallow source, avoid disturbing the sediment at edges or bottom.

Empty out a small portion of the water, so as to leave a small

space in the bottle for expansion. Return the stopper and press the edges of the tinfoil around the neck of the bottle.

Place in the mailing case. The shipping case contains sawdust. This box should be filled with cracked ice mixed with the sawdust and the cover put on tightly.

The shortest possible time should elapse between sampling and shipping by express.

2 Lab. No. —. Section No. —. Bed No. —.

Information Relating to Sample of Oysters Submitted for Analysis.

(To be filled in by person taking samples.)

Date of Collection, —— —, ——.
Collected by, —— ——.
Description of source, ——.
General location of bed, ——.
Hour of Collection, ——.

(Give name of bay, harbor, cove, pond, river or creek in which bed lies and name of town in case of an inside bed.)

Official designation of bed including number, etc. ——.
Give distance from nearest point on shore or from light-house or charted buoy and state compass direction from locating point. ——.
State whether bed lies near mouth of a river or creek. ——.
Depth of water over bed, ——.
Kind of bottom—hard or soft, ——.
Wind—direction, ——.
Tide, ——.
Sand, Clay or Mud, ——.
Velocity—strong or light, ——.
Weather, ——.

After filing out blank, place in envelope and attach to box containing oysters from corresponding bed.

COMPLAINANTS' EX. No. 184. James D. Maher, Commissioner.

Water Samples.

Section 14, Bed 490.

Date.	Time Collected.	Date.	Time Collected.
9/23/11	5.15 a. m.	6 /3/12	
10/11/11		6 /7 12	
10/21/11		6/11/12	
11/ 4/11		6/17/12	
11/15/11		6/25/12	
11/23/11	9.15 a. m.	7/ 2/12	
12/ 2/11	7.45 a. m.	7/ 9/12	
12/ 9/11		7/16/12	
12/16/11		7/24/12	
4/ 2/12		7/30/12	
4/ 4/12		8/ 6/12	
4/10/12		8/14/12	
4/12/12		8/20/12	
4/12/12		8/28/12	
4/16/12	5.30 p. m.		
4/19/12			
4/22/12			
4/28/12			
4/29/12			
5 /2/12			
5/ 6/12			
5/10/12			
5/14/12			
5/16/12			
5/21/12			
5/24/12			
5/27/12			
5/31/12			

COMPLAINANTS' EX. No. 185. James D. Maher, Commissioner.

Oysters.

Section 14, Bed 490.

Date.	Time Collected.	Date.	Time Collected.
8/ 1/10		5/14/12	
9/14/10		5/16/12	
5/ 6/10		5/21/12	
8/28/11	7.15 a. m.	5/24/12	
9/ 9/11	9.15 a. m.	5/27/12	
9/23/11	5.15 a. m.	5/31/12	
10/11/11	11.20 a. m.	6/ 3/12	
10/21/11	8.30 a. m.	6/ 7/12	
11/ 4/11	6.20 a. m.	6/11/12	
11/15/11	10.30 a. m.	6/17/12	
11/23/11	9.15 a. m.	6/25/12	
12/ 2/11	7.45 a. m.	7/ 2/12	
12/ 9/11	9.15 a. m.	7/ 9/12	
12/16/11	4.15 a. m.	7/16/12	
3/28/12		7/24/12	
4/ 2/12		7/30/12	
4/ 4/12		8/ 6/12	
4/10/12		8/14/12	
4/12/12		8/20/12	
4/16/12	5.30 p. m.	8/28/12	
4/19/12	8 a. m.		
4/22/12	12.30 p. m.		
4/25/12	10.20 a. m.		
4/29/12	11.30 a. m.		
5/ 2/12			
5/ 6/12	7 a. m.		
5/10/12	10 a. m.		

COMPLAINANTS' EX. No. 186. James D. Maher, Commissioner.

Water.

Section 14, Bed 924.

Date.	Time Collected.
9/23/11	5.30 a. m.
10/11/11	
10/21/11	
11/ 4/11	
11/15/11	
11/23/11	9 a. m.
12/ 2/11	7.30 a. m.
12/ 9/11	
12/15/11	

COMPLAINANTS' EX. No. 187. James D. Maher, Commissioner.

Oysters.

Section 14, Bed 924.

Date.	Time Collected.
9/14/10	
9/14/10	
5/ 6/11	
8/28/11	7 a. m.
8/28/11	7 a. m.
8/28/11	7 a. m.
9/ 9/11	9 a. m.
9/23/11	5.30 a. m.
10/11/11	11.15 a. m.
10/21/11	7.30 a. m.
11/ 4/11	6.30 a. m.
11/15/11	10.15 a. m.
11/23/11	9 a. m.
12/ 2/11	7.30 a. m.
12/ 9/11	9 a. m.
12/16/11	4 a. m.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 188.

Showing Report of Bacteriological Examinations of Samples of Water and Oysters of Bed No. 490.

JAMES D. MAHER,
Commissioner.

LESCHLE LABORATORIES
[illegible] 28th Street
NEW YORK CITY

Gov't Exhibit No. 18
James D. Maher
Examiner

REPORT

In the matter of

RESULTS OF BACTERIOLOGICAL EXAMINATIONS

OF SAMPLES OF OYSTERS AND WATER

COLLECTED BY C. W. SANDRS

FROM THE WATERS OF OYSTER BED #490,

(DELINEATION OF THE BUREAU OF MARINE FISHERIES

CONSERVATION COMMISSION NEW YORK STATE),

AND DELIVERED BY HIM.

* * *

Report to

LEDERLE LABORATORIES

[illegible] WEST [illegible]TH STREET

NEW YORK CITY

No.

Ex 185-P 2

Lab. No.	Date Collected	Tide	Wind		Weather Condition	Oysters		
			Direct	Velocity		Bacteria per C.C.	Score	
							Total	Single
54,892	9/1/11	Flood	S. E.	Strong	Fair		230	57.5
56,165	9/14/11	L.of Ebb	N. E.	Strong	Cloudy		32	8.4
61,571	9/6/11						3	0.6
70,726	9/28/11	1st of Flood	S.	Light		1,170,000	410	82.0
71,195	9/9/11	High	E.	Light	Cloudy	170	14	2.8
71,783	9/23/11	1st of Flood	N. E.	Strong	Clear	1,800	41	8.2
72,882	10/11/11	Ebb	S. W.		Rain	110	41	8.2
73,198	10/21/11	1st of Ebb	E.	Strong	Rain	2,300	32	6.4
76,071	11/6/11	High	W.	Light	Cloudy	23,000	50	10.0
76,665	11/15/11	1st of Flood	W.	Strong	Clear	360	5	1.0
75,169	11/23/11	High	S.	Light	Clear	480	4	0.8
75,692	12/2/11	1/2 Ebb	W.	Light	Cloudy	430	2	0.4
76,078	12/9/11	High		Calm	Hazy	800	5	1.0
76,082	12/16/11	High	S.	Light	Rain	2,000	14	2.8
	3/20/12		N.W.	Brisk	Clear			
	3/24/12		S.	Light	Rain			
81,913	3/28/12	1/2 Ebb		Calm	Cloudy	278	14	2.8
	3/30/12	1/2 Flood	N.	Light	Clear			
	4/1/12	1/2 Ebb	S.	Light	Part Cloudy			
82,491	4/2/12	1/2 Ebb	E.	Calm	Rainy	320	2	0.4
82,891	4/4/12	Low	W.	Strong	Clear	180	1	0.2
	4/5/12	1/2 Flood	W.	Brisk	Clear			

B. COLI IN			Water					
			Lab. Number	Temp. F °	Gelatine Count 48 hrs. @ 20°C	Agar Count 48 hrs. @ 37° C.	B. COLI IN	
1.0 c.c.	0.1 c.c.	0.01 c.c.					0.1 c.c.	1 c.c.
3 + 0 -	4 + 0 -	2 + 1 -						
5 + 0 -	3 + 2 -	5 + 0 -						
3 + 2 -	2 + 3 -	0 + 5 -						
5 + 0 -	5 + 0 -	4 + 1 -						
5 + 0 -	1 + 4 -	0 + 5 -						
5 + 0 -	4 + 1 -	0 + 5 -	71,762		9,200	40	-	+
5 + 0 -	4 + 1 -	0 + 5 -	72,384		72,000	4,000	-	+
5 + 0 -	3 + 2 -	0 + 5 -	73,193		550	150	+	+
5 + 0 -	5 + 0 -	0 + 5 -	74,073		300	17	+	+
5 + 0 -	0 + 5 -	0 + 5 -	76,667		77	130	-	+
4 + 1 -	0 + 5 -	0 + 5 -	78,171		Liquefied	700	+	+
2 + 3 -	0 + 5 -	0 + 5 -	78,694		130	100	-	+
5 + 0 -	0 + 5 -	0 + 5 -	78,080		2,800	170	-	+
5 + 0 -	1 + 4 -	0 + 5 -	78,584		10,000	150	-	+
				37.5				
				33.0				
5 + 0 -	1 + 4 -	0 + 5 -		34.0				
				39.0				
				39.0				
2 + 3 -	0 + 5 -	0 + 5 -	82,491	42.0	500	110	-	+
1 + 4 -	0 + 5 -	0 + 5 -	82,892	42.0	380	95	-	+
				39.0				

Report re

LEDERLE LABORATORIES

39-41 WEST 38TH STREET
NEW YORK CITY

No.

Ex. 188-P 3

LAB. NO.	DATE COLLECTED	TIDE	WIND		WEATHER CONDITION	OYSTERS			B. COLI IN			WATER						
			DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE		1.0 c.c.	0.1 c.c.	0.01 c.c.	LAB. NUMBER	TEMP. F°	Gelatine Count 48 hrs.@ 20°C	Agar Count 24 hrs. @ 37° C.	B. COLI IN		
							Total	Single								0.1 c.c	1 c.c.	10 c.c.
	4/8/12	1/2 Flood	S.W.	Light	Clear								41.0					
	4/8/12	1/2 Flood	N.W.	Strong	Clear								36.0					
	4/9/12	L.of Ebb	W.	Brisk	Clear								40.0					
82,881	4/10/12	1/2 Ebb	S.W.	Light	Rain	4,100	2	0.4	2 + 3 -	0 + 5 -	0 + 5 -	82,882	43.0	500	46	-	+	+
	4/11/12		W.	Brisk	Clear								43.0					
83,082	4/12/12	Low	E.	Light	Clear	35,000	5	1.0	5 + 0 -	0 + 5 -	0 + 5 -	83,083	44.0	49,000	2,600	-	+	+
	4/13/12	1/2 Ebb	E.	Brisk	Rainy								44.0					
	4/15/12	1/2 Flood	E.	Moderate	Part Cloudy								45.0					
83,240	4/16/12	High	N.	Light	Cloudy	1,120	32	6.4	5 + 0 -	3 + 2 -	0 + 5 -	83,241	49.0	27,000	141	-	+	+
	4/17/12	L. of Flood	E.	Light	Rain								50.0					
	4/18/12	L. of Flood	E.	Light	Rain								46.0					
83,401	4/19/12	L. of Flood	W.	Brisk	Rain	600	5	1.0	5 + 0 -	0 + 5 -	0 + 5 -	83,402	46.0	2,100	80	+	+	+
	4/20/12	1/2 Ebb	N.W.	Brisk	Clear								46.0					
83,596	4/22/12	1/2 Ebb	E.	Light	Cloudy	375	4	0.8	4 + 1 -	0 + 5 -	0 + 5 -	83,597	54.0	55,000	41	+	+	+
	4/24/12	L. of Flood	W.	Brisk	Clear								47.0					
83,804	4/25/12	1/2 Flood	W.	Strong	Clear	800	2	0.4	2 + 3 -	0 + 5 -	0 + 5 -	83,805	47.0	160,000	90	-	+	+
	4/27/12		S.E.	Light	Clear								49.0					
83,993	4/29/12	L. of Ebb	E.	Brisk	Rain	2,500	14	2.8	5 + 0 -	1 + 4 -	0 + 5 -	83,994	47.0	13,500	100	+	+	+
	4/30/12		E.	Brisk	Rain								47.0					
	5/1/12		S.	Light	Clear								48.0					
84,175	5/2/12	1/2 Flood	W.	Brisk		800	14	2.8	5 + 0 -	1 + 4 -	0 + 5 -	84,176	48.0	550	65	-	+	+
	5/3/12	High	S.	Light	Clear								48.0					

Report re _____ No. _____

LEDERLE LABORATORIES

39-41 WEST 38TH STREET
NEW YORK CITY

Ex 188-P.4

LAB. NO.	DATE COLLECTED	TIDE	WIND		WEATHER CONDITION	OYSTERS			B. COLI IN			WATER						B. COLI IN		
			DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE		1.0 c.c.	0.1 c.c.	0.01 c.c.	LAB. NUMBER	TEMP. F°	Gelatine Count 48 hrs.@ 20°C	Agar Count 24 hrs. @ 37° C			0.1 c.c.	1 c.c.	10 c.c.
							Total	Single												
	5/4/12	1/2 Flood	W.	Light	Clear								49.0							
84,380	5/6/12	1/2 Flood	E.	Brisk	Cloudy	900	5	1.0	5 + 0 -	0 + 5 -	0 + 5 -	84,381	51.0	550	39			-	+	+
	5/7/12	Low	E.	Moderate	Rain								50.0							
	5/8/12	1/2 Flood	E.	Moderate	Rain								51.0							
	5/9/12	Low	W.	Moderate	Showers								50.0							
84,754	5/10/12	1st Flood	N. W.	Strong	Clear	4,500	23	4.6	5 + 0 -	2 + 3 -	0 + 5 -	84,755	51.0	17,600	38			-	-	+
	5/11/12	Low	S.E.	Brisk	Part Cloudy								52.0							
	5/13/12	1/2 Ebb	S.	Brisk	Showers								56.0							
84,915	5/14/12	High	N.W.	Brisk	Clear	350	14	2.8	5 + 0 -	1 + 4 -	0 + 5 -	84,916	52.0	Liquefied	35			-	+	+
	5/15/12	1st of Ebb	E.	Brisk	Rainy								52.0							
85,032	5/16/12	L. of Flood		Calm	Rainy	4,500	50	10.0	5 + 0 -	5 + 0 -	0 + 5 -	85,033	59.0	Liquefied	50			-	+	+
	5/17/12	L. of Flood	W.	Brisk	Clear								60.0							
	5/18/12	1/2 Flood	W.	Brisk	Clear								60.0							
	5/20/12	1st Flood	E.	Moderate	Clear								55.0							
85,310	5/21/12	1st of Ebb	W.	Strong	Clear	2,600	23	4.6	5 + 0 -	2 + 3 -	0 + 5 -	85,311	59.0	35,800	190			-	+	+
	5/22/12	1st of Ebb	W.	Brisk	Clear								58.0							
85,468	5/23/12	Low	E.	Light	Part Cloudy	640	32	6.4	5 + 0 -	3 + 2 -	0 + 5 -	85,469	56.0	300	40			-	+	+
	5/24/12	L. of Ebb	S.E.	Moderate	Part Cloudy								59.0							
	5/25/12	L. of Ebb	N.W.	Moderate	Clear								67.0							
85,630	5/27/12	1st of Ebb	S.	Light	Clear	38,000	50	10.0	5 + 0 -	5 + 0 -	0 + 5 -	85,631	62.0	2,500	300			-	+	+
	5/28/12	High	S.	Brisk	Cloudy								60.0							

Report to

LEDERLE LABORATORIES

39-41 WEST 38TH STREET
NEW YORK CITY

No.

Ex 188-P.5

LAB. NO.	DATE COLLECTED	TIDE	WIND		WEATHER CONDITION	OYSTERS		
			DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE	
							Total	Single
	5/29/12	L. of Flood	W.	Moderate	Clear			
	5/30/12	1st of Ebb	S.E.	Moderate	Cloudy			
85,928	5/31/12	1/2 Flood	N. W.	Strong	Clear	2,900	5	1.0
86,090	6/3/12	1/2 Flood	W.	Light	Clear	21,000	410	82.0
	6/6/12	1/2 Ebb	S.	Brisk	Rainy			
86,386	6/7/12	1/2 Ebb	N. W.	Strong	Clear	29,000	140	28.0
86,539	6/11/12	High	N.W.	Moderate	Clear	2,000	23	4.6
86,944	6/17/12	1st Flood		Calm	Cloudy	Uncountable	500+	100+
87,470	6/23/12	High	S.	Light	Showers	4,200	23	4.6
87,825	7/2/12	1/2 Flood	S. W.	Brisk	Clear	7,000	23	4.6
88,210	7/9/12.	L. of Ebb		Calm	Cloudy	520,000	32	6.4
88,533	7/16/12	L. of Flood		Calm	Cloudy	2,600	140	28.0
89,068	7/24/12	1/2 Ebb	N. W.	Light	Cloudy	230	4	0.8
89,609	7/30/12	L. of Flood		Calm	Clear	6,900	5	1.0
90,353	8/6/12	1/2 Ebb	S.	Moderate	Cloudy	400	5	1.0
90,916	8/14/12	1/2 Flood	N. W.	Moderate	Cloudy	7,400	230	46.0
91,372	8/20/12	1/2 Ebb	S. E.	Brisk	Cloudy	3,000	320	64.0
91,901	8/28/12	1st Flood	S. W.	Brisk	Cloudy	3,000	5	1.0
92,273	9/4/12	Low	S.	Light	Fog	3,200	32	6.4

WATER									
B. COLI IN			LAB. NUMBER	TEMP. F °	Gelatine Count 48 hrs.@ 20°C	Agar Count 24 hrs. @ 37° C	B. COLI IN		
1.0 c.c.	0.1 c.c.	0.01 c.c.					0.1 c. c.	1 c.c.	10 c.c.
				62.0					
				62.0					
5 + 0 -	0 + 5 -	0 + 5 -	85,929	62.0	3,600	800	-	+	+
5 + 0 -	5 + 0 -	4 + 1 -	86,091	62.0	150,000	74,000	-	+	+
				62.8					
5 + 0 -	5 + 0 -	1 + 4 -	86,387	60.0	8,500	500	-	+	+
5 + 0 -	2 + 3 -	0 + 5 -	86,540	61.0	7,000	300	-	+	+
5 + 0 -	5 + 0 -	5 + 0 -	86,945	62.0	45,000	500	-	+	+
5 + 0 -	2 + 3 -	0 + 5 -	87,469	70.0	4,000	300	-	+	+
5 + 0 -	2 + 3 -	0 + 5 -	87,825	75.0	170	23	-	+	+
5 + 0 -	3 + 2 -	0 + 5 -	88,209	77.0	650	2	-	-	+
5 + 0 -	5 + 0 -	1 + 4 -	88,534	74.0	4,000	2,100	-	+	+
4 + 1 -	0 + 5 -	0 + 5 -	89,069	70.0	60	40	-	-	+
5 + 0 -	0 + 5 -	0 + 5 -	89,610	72.0	2,300	90	-	+	+
5 + 0 -	0 + 5 -	0 + 5 -	90,352	69.0	14	3	-	-	-
5 + 0 -	5 + 0 -	2 + 3 -	90,917	75.0	11,700	1,400	-	+	+
5 + 0 -	5 + 0 -	3 + 2 -	91,373	72.0	3,800	4,200	-	+	+
5 + 0 -	0 + 5 -	0 + 5 -	91,900	69.0	3,900	46	-	-	+
5 + 0 -	3 + 2 -	0 + 5 -	92,274	66.0	16	90	-	+	+

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 189.

Showing Report of Bacteriological Examinations of Samples of Oysters.

JAMES D. MAHER,
Commissioner.

LEDERLE LABORATORIES
30-41 West 35th Street
NEW YORK CITY

Griffgawants Ex. No. 189
James D. Maher
Commissioner

REPORT

In the matter of

RESULTS OF BACTERIOLOGICAL EXAMINATIONS
OF SAMPLES OF OYSTERS
COLLECTED BY G. W. SANBOS
FROM THE WATERS OF OYSTER BEDS
(DESIGNATION OF THE BUREAU OF MARINE FISHERIES
CONSERVATION COMMISSION NEW YORK STATE),
IN RARITAN BAY AND
DELIVERED BY HIM.

* * *
* *
*

Report to

No.

Ez184-P2.

LEDERLE LABORATORIES

39-41 WEST 38th STREET

NEW YORK CITY

LAB. NO.	DATE COLLECTED	BED NO.	TIDE	WIND DIRECT.	WIND VELOCITY	WEATHER CONDITION	OYSTERS — BACTERIA PER C.C.	OYSTERS — SCORE Total	OYSTERS — SCORE Single	OYSTERS — B. COLI IN 1.0 c.c.	OYSTERS — B. COLI IN 0.1 c.c.	OYSTERS — B. COLI IN 0.01 c.c.
54,935	8/1/10	463	Flood	S. E.	Strong	Fair		140	28.0	5 + 0 -	5 + 0 -	1 + 4 -
56,756	9/14/10	463	1st Flood	N. E.	Strong	Cloudy		50	10.0	5 + 0 -	5 + 0 -	0 + 5 -
65,972	5/8/11	463						14	2.8	5 + 0 -	1 + 4 -	0 + 5 -

Report to

LEDERLE LABORATORIES

30-41 WEST 30th STREET

NEW YORK CITY

No.

Ex 189-P 3.

LAB. NO.	DATE COLLECTED	BED NO.	TIDE	WIND		WEATHER CONDITION	OYSTERS				
				DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE		B. COLI IN	
								Total	Single	1.0 c.c.	0.1 c.c.	0.01 c.c.
84,831	9/1/10	498	Flood	S. E.	Strong	Fair	14	2.8	5 + 0 -	1 + 4 -	0 + 5 -
86,347	9/14/10	498	1st Flood	E. S.	Strong	Cloudy	23	4.6	5 + 0 -	2 + 3 -	0 + 5 -
86,346	9/14/10	289	1st Flood	E. S.	Strong	Cloudy	32	6.4	5 + 0 -	3 + 2 -	0 + 5 -
88,570	9/8/11	787					2	0.4	2 + 3 -	0 + 5 -	0 + 5 -

Report re _____

LEDERLE LABORATORIES

39-41 WEST 38TH STREET
NEW YORK CITY

No._____

Ex 189-P 4.

LAB. NO.	DATE COLLECTED	BED NO.	TIDE	WIND		WEATHER CONDITION	OYSTERS				
				DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE		E. COLI IN		
								Total	Single	1.0 c.c.	0.1 c.c.	0.01 c.c.
56,354	9/14/10	688	L. of Ebb	N. E.	Strong	Cloudy		32	6.4	5 + 0 -	3 + 2 -	0 + 5 -
70,727	8/28/11	688	1st Flood	S.	Light		50,000	320	64.0	5 + 0 -	5 + 0 -	3 + 2 -
71,186	9/9/11	688	High	E.	Light	Cloudy	290	32	6.4	5 + 0 -	3 + 2 -	0 + 5 -
56,353	9/14/10	354	L. of Ebb	N. E.	Strong	Cloudy		23	4.6	5 + 0 -	2 + 3 -	0 + 5 -

Ex 189-P.5.

Report re

LEDERLE LABORATORIES

39-41 WEST 38TH STREET
NEW YORK CITY

No.

LAB. NO.	DATE COLLECTED	BED NO.	TIDE	WIND		WEATHER CONDITION	OYSTERS				
				DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE		B. COLI IN		
								Total	Single	1.0 c.c.	0.1 c.c.	0.01 c.c.
54,834	8/1/10	891	Flood	S. E.	Strong	Fair		41	8.2	5 + 0 -	4 + 1 -	0 + 5 -
56,350	9/14/10	891	L.of Ebb	N. E.	Strong	Cloudy		50	10.0	5 + 0 -	5 + 0 -	0 + 5 -
56,349	9/14/10	913	L.of Ebb	N. E.	Strong	Cloudy		23	4.6	5 + 0 -	2 + 3 -	0 + 5 -
56,349	9/14/10	929	L.of Ebb	N. E.	Strong	Cloudy		23	4.6	5 + 0 -	2 + 3 -	0 + 5 -
54,832	8/1/10	966	Flood	S. E.	Strong	Fair		41	8.2	5 + 0 -	4 + 1 -	0 + 5 -
56,351	9/14/10	966	L.of Ebb	N. E.	Strong	Cloudy		41	8.2	5 + 0 -	4 + 1 -	0 + 5 -

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 190.

Showing Report of Bacteriological Examinations of Samples of Oysters and Water.

JAMES D. MAHER,
Commissioner.

19

IRLE LABORATORIES
341 West 38th Street
NEW YORK CITY

Conf law and Ex. Dr. 190.
James D. Maher
Commissioner

REPORT

In the matter of

RESULTS OF BACTERIOLOGICAL EXAMINATIONS
OF SAMPLES OF OYSTERS AND WATER
COLLECTED BY G. W. SANDEN
FROM THE WATERS OF OYSTER BED #934,
(DESIGNATION OF THE BUREAU OF MARINE FISHERIES
CONSERVATION COMMISSION NEW YORK STATE),
AND DELIVERED BY HIM.

Report re

LEDERLE LABORATORIES

30-41 WEST 30th STREET
NEW YORK CITY

No.

Ex 190-P.2.

LAB. NO.	DATE COLLECTED	TIDE	WIND		WEATHER CONDITION	OYSTERS		
			DIRECT.	VELOCITY		BACTERIA PER C.C.	SCORE Total	SCORE Single
56,358	9/14/10	L.Ebb	N. E.	Strong	Cloudy		50	10.0
68,573	5/6/11						23	4.6
70,728	6/28/11	1st Flood	S.	Light	Cloudy	5,400	140	28.0
70,729	6/28/11	1st Flood	S.	Light	Cloudy	4,000	50	10.0
70,730	6/28/11	1st Flood	S.	Light	Cloudy	184,000	50	10.0
71,184	9/9/11	High	E.	Light	Cloudy	800	32	6.4
71,784	9/23/11	1/2Flood	N. E.	Strong	Clear	2,000	41	8.2
72,581	10/11/11	Ebb	S. W.		Rainy	210,000	140	28.0
73,199	10/21/11	High	E.	Strong	Rain	7,300	320	64.0
74,070	11/4/11	High	W.	Light	Cloudy	3,100	320	64.0
74,666	11/15/11	1st Flood	W.	Strong	Clear	300	14	2.8
75,170	11/23/11	High	S.	Light	Clear	80	4	0.8
75,691	12/2/11	1/2 Ebb	W.	Light	Cloudy	270	3	0.6
76,079	12/8/11	High		Calm	Hazy	300	14	2.8
76,521	12/15/11	High	E.	Light	Rainy	300	4	0.8

WATER										
B. COLI IN			LAB. NUMBER	TEMP. F. °	Gelatine Count 48 hrs.@ 20°C	Agar Count 24 hrs. @ 37° C	B. COLI IN		
1.0 c.c.	0.1 c.c.	0.01 c.c.					0.1 C.C.	1 c.c.	10 c.c.
5 + 0 -	5 + 0 -	0 + 5 -							
5 + 0 -	2 + 3 -	0 + 5 -							
5 + 0 -	5 + 0 -	1 + 4 -							
5 + 0 -	5 + 0 -	0 + 5 -							
5 + 0 -	5 + 0 -	0 + 5 -							
5 + 0 -	5 + 2 -	0 + 5 -							
5 + 0 -	4 + 1 -	0 + 5 -	71,761		5,700	115	-	+	+
5 + 0 -	5 + 0 -	1 + 4 -	72,583		150,000	1,300	-	-	+
5 + 0 -	5 + 0 -	3 + 2 -	73,198 A		1,300	1,900	+	+	+
5 + 0 -	5 + 0 -	3 + 2 -	74,072		250	16	-	+	+
5 + 0 -	1 + 4 -	0 + 5 -	74,668		230	160	+	+	+
4 + 1 -	0 + 5 -	0 + 5 -	75,172		Liquefied	210	+	+	+
3 + 2 -	0 + 5 -	0 + 5 -	75,693		100	75	+	+	+
5 + 0 -	1 + 4 -	0 + 5 -	76,081		700	150	-	+	+
4 + 1 -	0 + 5 -	0 + 5 -	76,525		6,600	36	-	+	+

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 191.

Showing Collection of Samples of Oysters from Bed 490.

JAMES D. MAHER,
Commissioner.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 192.

Showing Beds in Raritan Bay, Northport Division.

JAMES D. MAHER,
Commissioner.

Date.	Degrees F.
29th	49°
30th	44°
31st	39°

Average Mean Temperature for the Month of October, 1904, = 53.3°.

Average Mean Temperature for the Month of October, during past 40 years = 55.6°.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 194.

Showing Comparison of Tests for B. Coli in Samples of Water.

JAMES D. MAHER,
Commissioner.

Report re

LEDERLE LABORATORIES
30-41 WEST 58th STREET
NEW YORK CITY

No.

Complainant Ex. No. 194
James D. Maher
Commissioner

COMPARISON OF RESULTS OF TESTS FOR B. COLI IN SAMPLES OF WATER

WITH

RESULTS OBTAINED FROM THE EXAMINATION OF THE SHELL LIQUOR OF OYSTERS OBTAINED FROM SAMPLING STATIONS IN CLOSE PROXIMITY.

Taken from Table on Page 892,

28th Annual Report, Vol. II, New York State Dept. of Health.

INSIDE GREAT KILLS

	Sample Number	Approximate B. Coli Score	Tests for B. Coli 10 c.c.	1 c.c.		0.1 c.c.		0.01 c.c.	
				0+	2-	0+	2-	0+	2-
Water	42.1			0+	5-				
Oysters	134.2								
"	98.2	Not given				2+	3-		
"	133.2	14		3+	2-	1+	1-		
"	94.2								
"	132.2	23				1+	4-		
"	93.2					4+	1-		

OFF GREAT KILLS POINT.

Water	99.1			0+	2-	0+	2-		
Oysters	130.2	8				1+	4-		
"	99.2			2+	3-				
"	131.2	23				2+	3-		
"	92.2			4+	1-	1+	4-		
"	137.2	32				3+	2-		
"	98.2			5+	0-				
"	128.2	23				2+	0-		
"	96.2			5+	0-				

Report re

LEDERLE LABORATORIES
30-41 WEST 58TH STREET
NEW YORK CITY

No.

Ex. 194-P 2.

SOUTH GREAT KILLS POINT.

	Sample Number	Approximate B. Coli Score	Tests for B. Coli. 10 c.c.	1 c.c.	0.1 c.c.	0.01 c.c.
Water	43.1			0+ 2-	0+ 2-	0+ 2-
"	44.1			0+ 2-	0+ 2-	0+ 2-
"	45.1			0+ 3-	0+ 2-	0+ 2-
"	48.1		2+ 0-	0+ 2-	0+ 2-	
"	49.1		1+ 1-	1+ 1-	0+ 2-	
Oysters	73.2	23		8+ 1-		
"	142.2				2+ 3-	
"	64.2	32		6+ 0-		
"	158.2				2+ 2-	0+ 4-
"	62.2	14		4+ 2-		
"	161.2				1+ 3-	0+ 4-
"	63.2	320		8+ 1-		
"	162.2				4+ 0-	3+ 1-
"	68.2	8		6+ 0-		
"	141.2	0			0+ 3-	

SOUTHWEST OF GREAT KILLS

Water	80.1		0+ 2-	1+ 1-	0+ 2-	
"	89.1		0+ 2-	2+ 0-	0+ 2-	
Oysters	68.2	14		6+ 0-		
"	157.2				1+ 3-	
	71.2	14				
	163.2					

OFF PRINCESS BAY.

Water	82.1		2+ 0-	0+ 2-	0+ 2-	
Oysters	168.2	41		8+ 0-	2+ 0-	
"	103.2					

BEDS EAST OF TOTTENVILLE.

Water	83.1		1+ 0-	0+ 2-	0+ 2-	
Oysters	166.2	140			4+ 0-	1+ 3-
"	104.2			3+ 0-		

1 COMPLAINANTS' EX. No. 195. James D. Maher, Commissioner.

Weekly Report to Dr. H. D. Pennypacker Lederle Laboratories, on Sanitary Inspection of South Shore of Staten Island for Sealshipt Oyster System, Inc.

In order to locate private sewer outlets on the south shore of Staten Island between South Beach and Tottenville, I visited the Department of Public Works at Borough Hall, St. George, S. I. There are no maps in the Department showing these private sewer outlets.

Outlets of public sewerage system at Tottenville obtained.

In order to bring up to date locations of sewer outlets given in 1908, report of N. Y. State Board of Health, I began a sanitary inspection of the above shore.

The results of these inspections are given on following pages.

July 1st, 1910.

2 June 20, 1910.

South Beach, S. I.

There are three (3) sewers along this beach discharging into the lower bay, the outlets being located just beyond low water mark.

1. In front of Happyland entrance, 6" iron pipe, under pier, outlet 50' beyond low water mark.

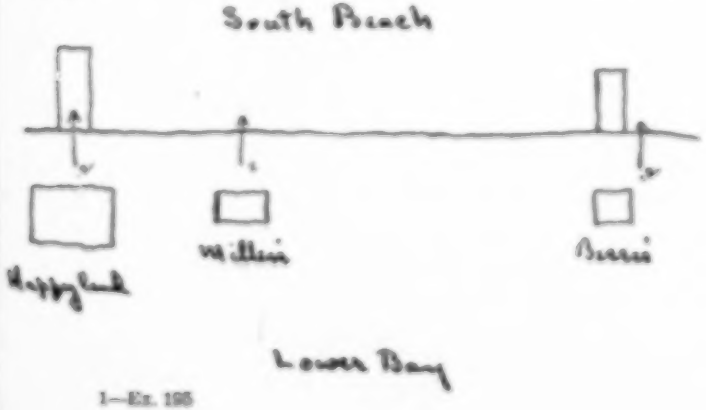
2. In front of Miller's Hotel small sewer discharges under pile of rocks 20' beyond low water mark.

3. In front of Bessi's Hotel small sewer discharges under pile of rocks about 20' beyond low water mark.

Most of the hotels and cottages have cesspools or privies. These do not directly pollute the bay and the polluting matter is probably pretty thoroughly filtered out before the bay is reached.

There are bathing beaches along this whole shore front.

Up to the present time comparatively few people have visited the resort.



3 June 21, 1910.

Visited Metropolitan Sewerage Commission of New York #17 Battery Place. Dr. Soper out. Copied Raritan Bay records of Commission.

Float Records.

Courses of floats started in the Upper Bay, or in the Hudson or East Rivers and passing out through the Narrows.

Year 1907:

Out of 12 floats passing out through the Narrows on ebb tides—
8 took a course through the Main Ship Channel East of the Hoffman and Swinburne Islands and east of West Bank light.
2 passed out along the Coney Island Channel,
2 passed to the West as far as South Beach only—
Of these one grounded on the beach, the other returned on the next tide to the Narrows.

Year 1908:

Out of the three floats passing out through the Narrows on ebb tides—
1 passed along the Main Ship Channel east of Hoffman Island
1 " " " " Coney Island Channel,
1 went to the westward as far as South Beach only.

Year 1909:

Out of 5 floats passing out through the Narrows on ebb tides—
2 passed out through Ambrose Channel
2 passed out through Coney Island Channel
1 passed out through Main Ship Channel.
There is no record of any float passing from the Narrows to the Raritan Bay Oyster grounds.

Conclusion: The courses of floats, as observed by the Metropolitan Sewerage Commission in 1907, 1908 and 1909 would indicate that the Raritan Bay oyster grounds are not directly polluted by
4 New York sewage.

Copy of Records of Water Analyses of Raritan Bay Made by Metropolitan Sewerage Commission in 1909.

This commission did not regard the presumptive or lactose bile test as sufficient evidence of the presence of B. Coli in the water and decided that it was not practicable to carry out the isolation tests in each case.

They based their conclusions as to the pollution of the water at various points on the bacteria count and the percentage of dissolved oxygen saturation, combined with the results of the sanitary inspection.

The bacteria were plated out as soon as collected on the boat, on standard gelatin and grown for 48 hours. The dissolved oxygen determinations were also made on the boat as soon as the sample was collected, the A. Levy method being used.

5 JUNE 21, 1910.

Bacteria and Dissolved Oxygen in Raritan Bay Water.

Collected May 19, 1909. Low water—1:56 P. M. Wind—S. E.—10 miles per hour.

Location of Sample.	Depth.	Tide.	Bacteria per c. c.	Dis. Oxygen. % Saturation.
100′ north of Old Orchard light..	1′	Ebb.	1,100	100
	10′	"	700	100
100′ north of northern cable buoy.	1′	"	1,050	100
	10′	"	800	100
	20′	"	640	100
100′ north of southern cable buoy.	1′	"	1,200	100
	10′	"	900	100
	20′	"	840	100
200′ south of buoy S. I. W.....	1′	"	950	100
	10′	"	800	100
	20′	"	680	100
Midway between S. I. W. & Pt. Comfort	1′	"	820	100
	7′	"	740	100
500′ south of buoy 1½ off Seguine Point	1′	Flood.	1,100	100
	10′	"	900	100
	16′	"	700	100
500′ south of buoy N. of Seguine Point	1′	"	950	100
	10′	"	640	100
	20′	"	720	100

6 JUNE 21, 1910.

Bacteria and Dissolved Oxygen in Raritan Bay Water.

Collected September 20, 1909. Low Water, 5:54 P. M. Wind—S. E. 40 Miles. % Sea Water, 92. Temp. Water, 19°.

Location of sample.	Depth.	Tide.	Bacteria. per c. c.	Dis oxygen % Saturation.
200′ west of buoy S. I. W.....	1′	Ebb.	500	100
	12′	"	400	100
2 miles south of Great Kills.....	1′	"	400	100
	25′	"	...	100
1½ miles south of Great Kills..	1′	"	300	100
	15′	"	300	100
1 mile south of Great Kills.....	1′	"	550	100
	10′	"	250	100

Collected Sept. 21, 1909. L. W., 6 P. M. Wind—S. E., 5 Miles.

100′ east of buoy S. E. off Seguine Point	1′	Flood.	120	100
	20′	"	110	100
Near buoy S. E. off Seguine Pt...	1′	"	110	100
	25′	"	160	100
100′ southeast of Princess Bay light	1′	"	120	100
	20′	"	...	100
Near Red buoy S. 5.....	1′	"	120	100
	25′	"	200	100
Near Red buoy S. 8.....	1′	"	150	100
	25′	"	320	100
500′ north of Great Beds light...	1′	"	220	100
	16′	"	410	100

4433

7 June 21, 1910.

The 1906 report of the Metropolitan Sewerage Commission states that the oyster beds in New York bay are almost exclusively located on the southeast side of Staten Island and Gravesend Bay beyond the Narrows and concludes that most of the oyster and clam beds are free from dangerous pollutions, although there are some on the Staten Island shore near the narrows and the Kill von Kull and some in Gravesend Bay, which are nearer sewer outfalls than is proper.

The results of the bacteria and dissolved oxygen tests made by the same commission in 1909 confirm the above conclusion regarding the condition of the Raritan Bay oyster beds at the present time.

The beds were not dangerously polluted at points where the samples were taken but no samples were taken at points close to the private sewer outfalls or inside the Great Kills, where the pollution is probably greater.

It is generally stated that the ebb tide coming out of the Narrows and swinging toward Raritan Bay meets the ebb from Raritan Bay at points to the northeast of Elm Tree beacon, so that the sewage discharged from New York City does not under ordinary conditions pass over the oyster grounds in Raritan Bay during ebb tide.

8 June 22, 1910.

Midland Beach.

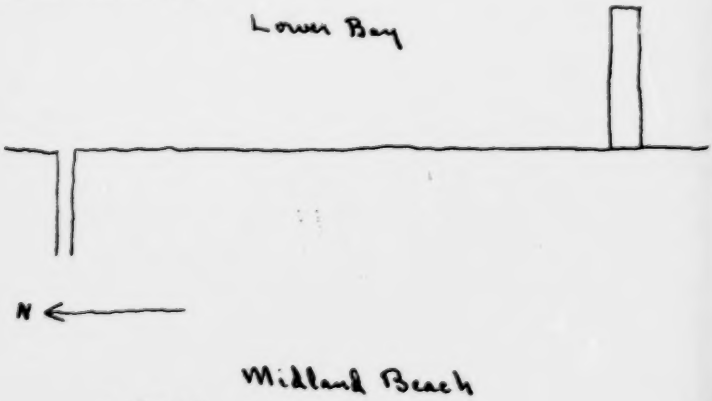
No sewers discharge directly into the lower bay at Midland Beach.

The privy system is almost universal with a few cesspools.

A few small sewers and cesspool overflow pipes discharge into trenches dug in the marshes back of the resort.

These trenches drain the mosquito-breeding swamps and eventually discharge their contents into the creek separating South Beach from Midland Beach, so that the sewage constituents may reach the bay through this creek.

1 main sewer discharges into trenches the sewage from 3 hotels and several cottages.



9 June 22, 1910.

New Dorp Beach.

There are three (3) sewers discharging into the bay along this beach.

A 6″ sewer pipe discharges just beyond low water mark in front of Boehm's Picnic Grounds. The outlet is under the pier.

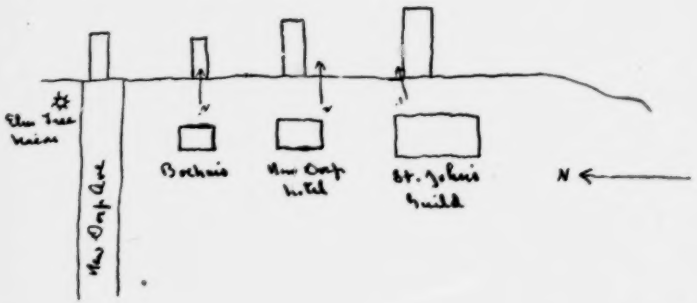
The greatest source of pollution along this beach is from the Seaside Hospital of St. John's Guild.

Just in front of the hospital beside the long pier is a 1½′ sewer outlet under a pile of rocks 20′ beyond low water mark.

The water contains many sewage particles especially toilet paper.

On the northern end of the bathing beach in front of the hospital there is another sewer outlet under a pile of rocks about 20′ beyond low water mark.

The other hotels and private houses have privies or cesspools. None of them directly pollute the bay.



10 June 23, 1910.

Great Kills.

The chief sources of pollution of the Great Kills are three sewers and one overhanging privy.

A small sewer discharges under a pile of rocks about 30′ beyond low water mark just south of Greenwadd's Hotel.

An overhanging privy in Sauer's Hotel pollutes the water the discharge being on land only at low water.

Just north of Sauer's Hotel a 2′ pipe discharges just above high water mark. It drains the swamps back of the hotels and received the sewage from Collin's Hotel, the sewer pipe entering the drain near the hotel. (So informed, pipe not seen.)

Just north of Gillie's Hotel a small sewer from the hotel discharges into the Kills.

The private houses to the north of the hotel section are mostly back from the shore and are provided with privies or cesspools which do not pollute the Kills, at least directly. One (1) privy near the shore may pollute the water in case of an overflow.

The brook entering the Kills at the Yacht Club drains an ice pond.

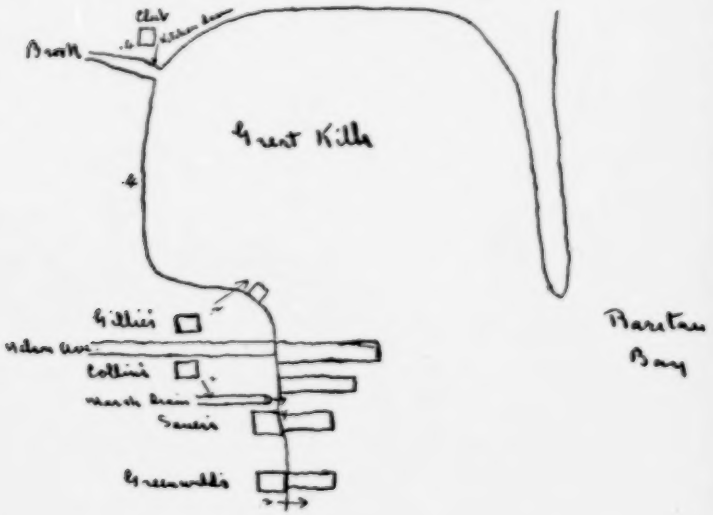
A drain enters it which discharges dishwater from the Yacht Club kitchen. No other sewage so far as could be learned is discharged into this brook. This brook was made the subject of a sensational article on shellfish pollution in the N. Y. Journal a few years ago.

11 June 23, 1910.

Great Kills.

The Yacht Club and private houses near this brook are provided with privies, which do not pollute the Kills directly. The Yacht Club privy would in case it overflowed, or in case of a very heavy rain.

The worst spot along the Kills is just north of Sauer's Hotel near the foot of Nelson Avenue, already described.



12 Jne 27, 1910.

Eltingville Shore.

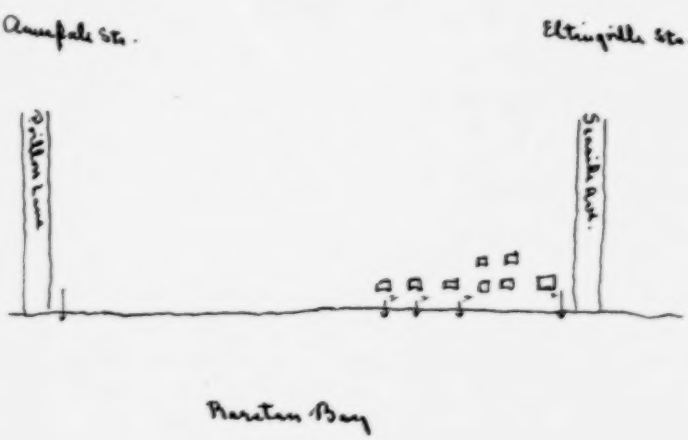
Just south of Great Kills near the foot of Seaside Avenue, Eltingville, there are about twenty (20) cottages and a fishing club near the shore.

Four (4) small sewers discharge the sewage from these houses, the outlets being under piles of rocks just beyond low water mark in three cases, and above high water mark in one cases.

The amount of discharge is very small.

Annadale Shore.

One small private sewer discharges into the bay near the foot of Poillon Lane.



13 June 24, 1910.

Latourette Pond.

The Schwab Foundling Hospital discharges the sewage from 200 inmates into a septic tank. After treatment, the efficiency of which is very doubtful, from mere inspection, it is discharged into the bay at the south side of the pier near low water mark.

The overflow brook from Latourette Pond empties into the bay near this same pier. There is another overflow north of the hospital grounds. It contains no sewage.

Two hundred feet south there is an overflow into the bay from a cesspool at Brunner's Hotel. At Winter's Hotel there is a privy 50 feet back from the shore.

Hug-enot Shore.

A large hotel, 200 capacity, the Terra Marine Inn, discharges its sewage direct into the Bay by a 6″ pipe. About 500 feet north of this, a wooden drain discharges sewage from a group of private houses.

Sequine Point.

The White Dental Works, 600 hands, discharges sewage from a one foot pipe at high water mark in front of the factory. Two private sewers, a one foot pipe and a 3″ x 1′ wooden drain, empty into Lemon Creek, near its outlet into Princess Bay.

There are two privies near the bank of creek and a one foot sewer pipe crosses the bed of the creek, heading toward Princess Bay. No outlet could be found, but pipe leaks into the creek from cracks.

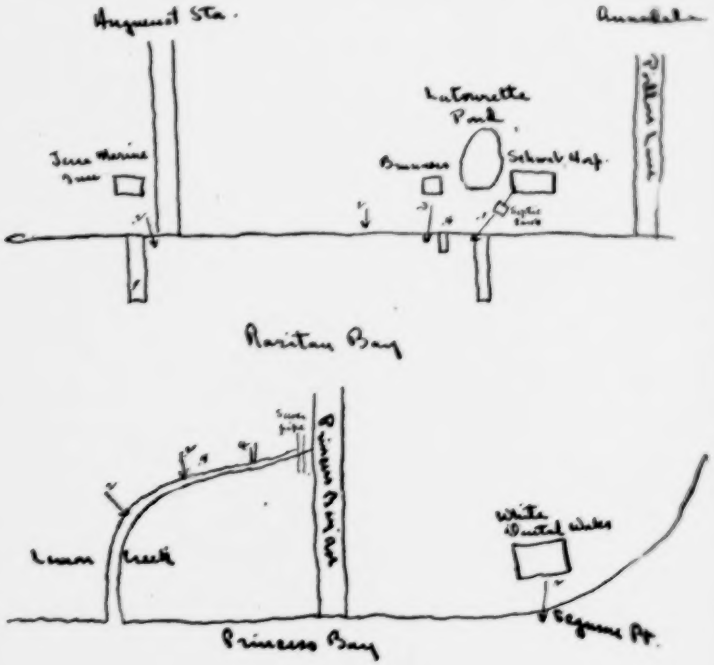
Red Bank.

The Loretto Mission, 200 inmates, discharges its sewage into the Bay at this point.

Tottenville.

Here there is a public sewer system with four outlets into
14 Arthur Kill. Two 6" pipes discharge sewage into the Kill near Perth Amboy ferry, near the large main sewer pipe.

On the Raritan Bay side of Tottenville, ten small private sewers discharge into the Bay; their combined discharge is not great.



Raritan Bay

June 25th, 1910.

Results of Inspections were plotted on U. S. C. & G. S. Chart #120.

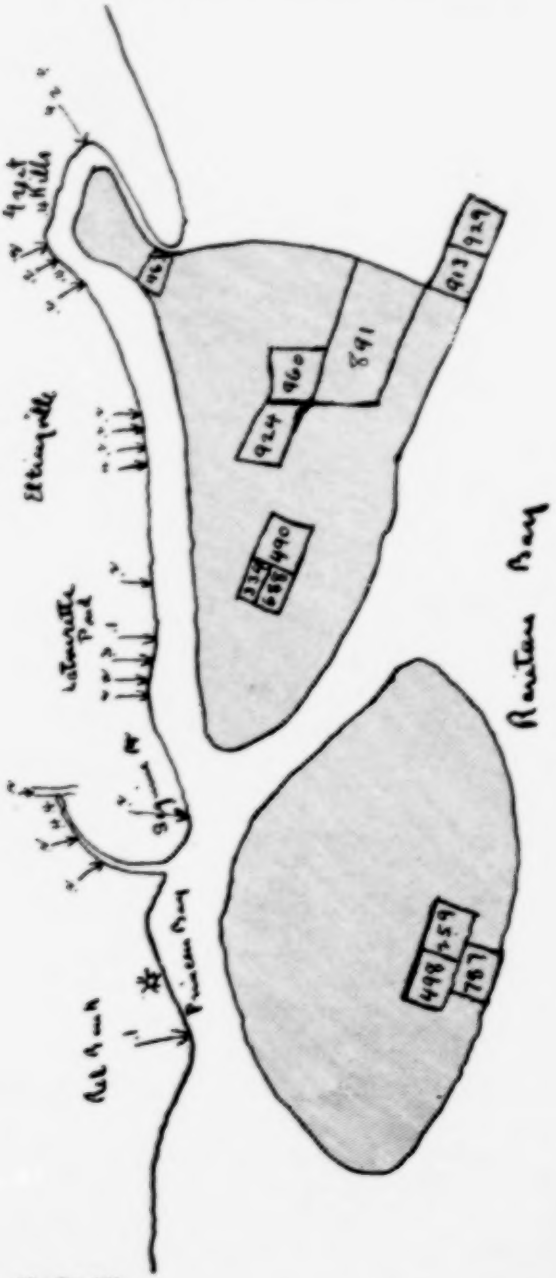
15 Conclusions.

Leaving out of account the Tottenville sewers discharging into Arthur Kill, which are so remote as to be comparatively unimportant, the pollution of the water of Raritan and New York lower bay- by sewers on the south shore of Staten Island is very slight. The heaviest points of discharge are at Red Bank, where the Loretto Mission is located, at Segamine Point from the White Dental Works and at New Dorp from St. Johns Guild.

Oyster beds located quite near the shore would undoubtedly feel the effect of the local sewers and this is especially true in Great Kills where some beds of other concerns are situated quite near the sewer outlets.

This shore of Staten Island is a place of summer residence almost entirely and during the chief part of the oyster season there would be very little sewage pollution with the exception of Loretto Mission and the White Dental Works.

PAYN B. PARSONS.


Atlantic Highlands
Sandy Hook
Raritan Bay
Raritan River
891
924
960
903
929
498
459
787

1 COMPLAINANTS' EXHIBIT No. 196. James D. Maher, Commissioner.

Lederle Laboratories,
39-41 West 38th Street, New York City.

Report in the Matter of Testing of Oysters for the Effect of Temperature upon the Activity of the Adductor Muscle Which Controls the Opening and Closing of the Oyster Shell.

2 Lederle Laboratories,
Sanitary, Chemical, and Bacteriological Investigations,
39-41 West 38th Street, New York City.

Joseph A. Deghuée, Ph. D.
Frederic D. Bell.
Harry E. Bramley.
Herbert D. Pease, M. D.

September 16th, 1912.

Report.

The sample of oysters was brought to me by Mr. George W. Sanbeg on September 14, 1912, from Bed #490, off Great Kills, Staten Island. These oysters were placed in a refrigerator held at a temperature of approximately 38° F. for over night. At the same time, several gallons of sea water which were collected off the Battery, showing a specific gravity test of 10/19 were likewise placed in the refrigerator until the next morning.

On the morning of September 15, seven (7) of the oysters and two (2) quarts of sea water were placed in separate vessels in another refrigerator and were cooled to 36° F. To the two (2) quarts of the sea water there was added 1/10 of a gram of Merck's Medicinal Fuchsin and thoroughly dissolved. This fuchsin solution was then added to the 7 oysters and the vessel containing the same was allowed to stand at a temperature of from 34 to 36° F. until 6:30 P. M. The entire group of 7 oysters was then washed in brine at a temperature of 35° C. for the purpose of washing off all traces of the fuchsin solution. Three of the oysters were then opened and the shell liquor collected in a flint glass bottle. Inspection of the opened oysters failed to show the slightest traces of fuchsin coloration on the inside of the shell, on the tissues of the oyster, or in the shell liquor. The shell liquor was preserved until the morning of the 16th, for the purpose of determining by daylight whether
3 the liquor *contains* the slightest tinge of fuchsin coloration. It was found that it was entirely without such coloration.

A fresh solution of fuchsin in 2 quarts of sea water of the same concentration was made, and the remaining 4 oysters of the 7 orig-

inally taken, were placed in this solution and left at room temperature. They were allowed to remain in this solution for a period of 22 hours at an average temperature of 65° F. At the end of that time, the oysters were opened and the following results noted: The gills of the oyster were turned a dark fuchsin color, the mantle were slightly discolored on the inner surfaces, the body of the oyster was not colored with the fuchsin to any extent. On opening the oysters, the shell liquor was found to be comparatively free from color. The inner surfaces of the shell were also uncolored.

Interpretation.

The results of this investigation would demonstrate that oysters kept in water at a temperature of 34 to 36° F. will remain closed, and that even water soluble dyes in solution of sea water fail to gain entrance to the cavities of the oyster inside of the shell. As the particles of these dyes in aqueous solution are infinitely smaller than the bodies of bacteria, it would be a warranted conclusion that the complete closure of the shell, such as occurs at this temperature, would be the means of total exclusion of the bacteria in the water surrounding the shell gaining entrance to the oyster inside of the shell.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

HERE FOLLOWS COMPLAINANTS' EXHIBIT No. 197.

Showing Report of Copper in Oysters.

JAMES D. MAHER,
Commissioner.

ECKERLE LABORATORIES
[illegible] West 30th Street
New York City

Complainant's Exhibit No. 199
James D. Morrell
Commissioner

REPORT

In the matter of

CHYRSA IN ORDERS

RESULTS OF TESTS FOR CHYRSA.

(IN TABULATED FORM)

Report re

LEDERLE LABORATORIES
39-41 WEST 38th STREET
NEW YORK CITY

No. _____

Ex.197-P.2

COPPER IN OYSTERS.

Lab.No.	Sec.	Location of Beds.	Percent of Copper	Weight of Copper per Oyster in mg.	Average Weight of Oysters in Gm.	Mg. per kilogram of Copper per Oyster	Color of Oysters	B.Coli Numer Value	Remarks
60,262	15	L.I. Sound - Duplicate Exam. by Bothe	.0107	1.00	9.65	107	All slightly green		
60,480	16	Narragansett bay - Hides Hole	.0083	1.65	19.538	83	All five white	0	
60,481	16	" " - Mt. Hope bay	.0125	2.04	16.246	125	" " "	4	
60,482	15	Long Island Sound - Spindle ground	.0782	6.40	8.175	782	All five very green	0	
60,483	15	" " " - Red #8	.0558	5.00	8.958	558	" " " "	3	
60,562	14	Princess bay #1 - Shipped to Cal. & returned	.0211	2.94	13.959	211	All five traces of green		
60,563	14	" " #2 - " " " " "	.0240	3.64	15.146	240	" " " " "		
60,576	20	San Francisco canned oysters - Bear brand	.0295	2.80	9.497	295	All five white	21,000	Shucked
60,577	20	" " " " - Antler brand	.0081	0.60	9.840	81	" " "	3	"
60,578	20	" " " " - Eagle brand	.0098	1.42	14.500	98	" " "	1-	"
60,579	20	Toke Point, Washington	.0080	1.10	13.792	80	" " "	41	
60,580	20	Shoal bay, California	.0086	0.15	1.706	86	" " "	140	
60,678	16	Narragansett bay, Quonset Point	.0087	1.14	13.064	87	" " "	0	
60,679	16	" " Rumstick Point	.0155	2.20	13.933	155	" " "	0	
61,359	14	Princess bay	.0219	3.80	17.324	219	" " "	1	
61,330	14	" "	.0394	7.10	18.008	394	All seven very green	5	
61,404	18	Wicomoko river	.0025	0.24	9.755	25	All five white	0	
61,405	18	Chesapeake bay. Poplar Island	.0046	0.52	11.374	46	" " "	3	
61,407	18	Potomac river	.0074	0.66	8.948	74	" " "	1	
61,408	18	Chesapeake bay	.0074	0.78	10.674	74	" " "	4	
61,410	18	James River	.0091	0.84	9.321	91	" " "	4	
61,412	18	Choptank river	.0076	0.72	9.440	76	" " "	4	
61,414	18	" "	.0036	0.24	6.535	36	" " "	4	
61,416	18	Severn river	.0091	0.80	8.795	91	" " "	2	
61,424	18	Potomac river	.0072	0.78	10.979	72	" " "	1	
61,425	18	Pocomoke sound, Chesapeake bay	.0027	0.35	13.051	27	" " "	14	
61,426	18	Potomac river	.0041	0.64	15.598	41	" " "	5	
61,427	18	Chesapeake bay. Tangier sound	.0022	0.19	8.337	22	" " "	3	
61,428	18	Pocomoke sound. Chesapeake bay	.0027	0.50	18.180	27	" " "	2	
61,429	18	Tangier sound. " " (Clams)	.0002	0.04	16.899	2	" " "	0	
61,430	18	" " " "	.0011	0.14	12.812	11	" " "	1	
61,431	18	Fishing bay	.0038	0.38	9.951	38	" " "	2	

Report re Copper in Oysters.

LEDERLE LABORATORIES

39-41 WEST 38th STREET
NEW YORK CITY

No. 2

Ex.197-P.3

Lab.No.	Sec.	Location of Beds.	Percent of Copper	Weight of Copper per Oyster in mg.	Average Weight of Oysters in Gm.	Mg. per kilogram of Copper per Oyster	Color of Oysters	B.Coli Numer. Value	Remarks
61,460	18	Machapreague Inlet. West bed	.0039	0.67	17.018	39	All five white		
61,465	18	Metomkin bay	.0019	0.33	17.827	19	" " "	0	
61,466	18	" "	.0007	0.12	17.47	7	" " "	1	
61,467	18	Wachipongo Inlet	.0024	0.30	12.893	24	" " "	0	
61,468	18	" "	Lost	---	------		" " "	1	
61,469	18	" "	.0038	0.30	8.668	38	" " "	0	
61,470	18	Machapreague Inlet	.0028	0.40	14.126	28	" " "	1	
61,471	18	" "	.0023	0.37	15.894	23	" " "	2	
61,477	18	James River	.0060	0.84	13.914	60	" " "	3	
61,625	18	Potomac River	.0025	0.40	16.2811	25	" " "	4	
61,695	11	Great South Bay	.0043	0.54	12.519	43	" " "	0	
61,696	11	" " "	.0038	0.46	12.154	38	" " "	0	
61,697	11	" " "	.0036	0.64	17.856	36	" " "	0	
61,757	11	" " "	.0045	0.80	17.963	45	" " "	3	
61,758	18	Maddox Creek, br. of Potomac	.0063	0.94	14.944	63	" " "	14	
61,759	18	Potomac river. Piney Point	.0033	0.36	10.848	33	" " "	4	
61,760	18	Fishing bay. Chesapeake bay	.0023	0.26	11.160	23	" " "	2	
61,761	18	Nanticoke river	.0081	0.80	9.827	81	" " "	4	
61,762	18	Chesapeake bay	.0049	0.72	14.737	49	" " "	300	Shucked
61,763	18	" "	.0040	0.76	18.770	40	" " "	300	"
61,862	17	Upper N. Y. Bay. Robbins Reef	.0227	2.96	13.037	227	Four White. One traces of green.	14	
61,863	17	" " " " Oyster Is.	.0234	3.72	14.177	234	One White. Three traces of green and One very green.	41	
62,041	14	Princess bay	.0129	2.00	15.498	129	All five traces of green.		
62,042	14	" "	.0707	11.60	16.403	707	All five very green.		
62,210	21	Malpeque	.0032	0.30	9.262	32	All five white.	0	
62,292	18	York River	.0037	0.50	13.558	37	Four white. One traces of green.	3	
62,456	13	Jamaica bay. Bed 84	.0057	0.62	10.880	57	All five white.	2	
62,457	13	" " Bed 158	.0064	1.00	15.731	64	Four white. One traces of green on mantle.	4	
63,148	25	Best Dutch	.0009			9	All five white.	140	
63,150	25	Third Dutch	.0029			29	" " "	50	
63,151	24	Best Whitestables, English.	.0002			2	" " "	23	
63,154	24	Best Burnhams, English.	.0027			27	" " "	140	
63,155	24	Second Burnhams, English.	trace			--	" " "	41	

Ex.197-P.4

Report to

LEDERLE LABORATORIES

39-41 WEST 38TH STREET

NEW YORK CITY

No.

SUMMARY.

Average percent of copper in oysters not showing green coloration (51 samples - 255 oysters)- .0049

Average percent of copper in green oysters. (8 samples - 40 oysters) - .0391

Range of percent of copper in oysters not showing green coloration - .0295 to .0002

Range of percent of copper in green oysters - .0782 to .0107

Mg. per kilogram of copper
Average for oysters not showing green colorations - 49
Average for green oysters - 391

Range of copper in Mg. per kilogram of copper
In oysters not showing green colorations - 295 to 2
In green oysters - - 782 to 107

Location of beds for which greenest oysters came -
Long Island Sound - Spindle ground, south of Sheffield Island,
4 miles off South Norwalk, Conn.

1 PART OF COMPLAINANTS' EXHIBIT 198. (See page 11.)
James D. Maher, Commissioner.

U. S. Department of Agriculture, Weather Bureau, New York, N. Y.

Annual Meteorological Summary, 1912, with Comparative Data.

Published by authority of Willis L. Moore, Chief U. S. Weather Bureau. Compiled under the direction of James H. Scarr, District Forecaster.

Published by local office, U. S. Weather Bureau, New York, N. Y.

* * * * * * *

11 *Wind Direction.*

Monthly and Annual Percentage from—(Period 1894 to 1903, Inclusive.)

Month.	N.	N. E.	E.	S. E.	S.	S. W.	W.	N. W.	Calm.
January	8	13	6	4	6	15	18	30	0
February	7	12	5	4	6	12	19	33	0
March	9	12	9	9	10	10	12	29	0
April	9	14	8	12	10	10	11	27	0
May	7	12	10	14	14	15	11	17	0
June	5	8	9	13	17	18	11	19	0
July	5	9	6	10	19	24	12	16	0
August	8	10	7	12	16	17	11	17	0
September	8	13	6	10	16	17	10	20	0
October	9	16	8	7	10	16	12	22	0
November	7	12	5	4	9	16	17	29	0
December	10	11	5	4	8	18	19	26	0
Year	8	12	7	9	12	15	14	24	0

* * * * * * *

1 COMPLAINANT'S EXHIBIT 199. James D. Maher, Commissioner.

* * * * * * *

7 *Disposal of Sewage.*

This has been a most difficult problem and has been considered by committees of our boards, by civic bodies and by committees of citizens. We have had the opinion of the best experts on the subject. One point is conceded and that is no matter what system of sewage disposal is adopted Paterson must change from a combined to a separate system of sewers. For a year, at my direction, the City Engineer has been studying this question and worked out a plan by which we will be enabled to change our system for a great deal less than was first thought possible. The sewers built for the last two years have kept this plan in view.

The plan of the City Engineer for a separate system, which accompanies this message, should be adopted and put into operation. This can be done gradually and without being too great a burden.

Heretofore, the Lakeview section of the City has been neglected. At my direction, the City Engineer has prepared a plan for sewering this section, the development of which has been hindered by the lack of this necessary provision. A system could be extended through this section at a reasonable cost. The main trunk could be built for about $25,000, part of which could be assessed upon adjoining property, leaving probably from ten to fifteen thousand dollars to be raised by sale of bonds.

The Stony Road section is hindered by a like lack of sewage facilities, and the Engineer should be instructed to work out a plan for the sewage of that section.

The main question of disposal of the sewage has not been decided. If a trunk sewer can be built for the money reported by the Sewage Commission, and permission can be had to empty the same into New York Bay without purification works, then Paterson should join in the plan. If the sewage must be purified, as we have every reason to believe, then there is no reason for extending the sewer to New York Bay. The great expense of a tunnel to New York Bay should be avoided and the purification works built on Newark meadows.

Paterson will maintain the position that no matter what plan is adopted this City will not enter into any final contract with the Commission until the exact cost is ascertained by bids from reputable contracting firms.

8 Engineering works of this kind are generally estimated to cost considerably less than the final actual cost. We should be sure that the trunk sewer plan will cost us no more than a separate disposal works.

If the present financial management of the City is continued the City will be able to assume the burden of this problem without great detriment.

The likelihood of this burden being cast upon us has ever been uppermost in the minds of the Finance Commission and myself and makes it necessary that even stricter economy be practiced in the future in order to prepare for the shock which the assumption of the debt and expense of sewage disposal will cause the City.

* * * * * * * *

a COMPLAINANTS' EXHIBIT No. 200. James D. Maher, Commissioner.

NEW YORK CITY, May 19th, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York Sewage.

IV.

Study of the Collection and Disposal of the Sewage of the Upper East River and Harlem Division.*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.

July, 1912.

1 *Study of the Collection and Disposal of the Sewage of the Upper East River and Harlem Division.*

Honorable William J. Gaynor, Mayor of the City of New York.

SIR: In Preliminary Report No. 1, dated September, 1911, the Metropolitan Sewerage Commission divided the territory covered by the City of New York into four parts to facilitate the design of main drainage works for the protection of the harbor against excessive sewage pollution. The works for the Jamaica Bay Division, one of these parts, were described in a report dated December, 1911. The present report deals with a general plan for main drainage and sewage disposal for a second part, known as the Upper East River and Harlem Division, which embraces the land in the Boroughs of the Bronx and Manhattan, which drains to the Harlem river, and the land in the Boroughs of the Bronx and Northern Queens which drains to the Upper East river.

The plan here set forth is the result of careful study based on the outlook in the year 1912 for the municipal development of the region under consideration and on the existing state of the art of sewage disposal.

All the work planned will not be required in the immediate future, but it is regarded as necessary that such main drainage work as is undertaken by the city should conform to these plans, or such modifications of them as may be determined upon. The possibility

*This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

that a more complete system of main drainage than is here proposed may be needed in the distant future has been kept in mind in preparing these plans and it is believed that the works can be economically adapted to afford a more thorough protection of the harbor in the case of necessity.

The most prominent feature of the plan is the discharge of the sewage, after partial purification, into the large, deep tidal channels as near the sound entrance of the harbor as practicable.

The works are intended to deal with the dry-weather flow of sewage as collected in the lateral sewerage systems now built on the combined system. Where no sewers have yet been constructed, it will generally be desirable to build them on the separate system; this will not only facilitate a removal of the impurities, but contribute to economy of construction.

Topographical Features of the Division.

The Harlem river and the Upper East river determine the principal topographical features of this division. The Harlem
2 river runs through a narrow valley with shores which are in part densely populated, or are certain to become so at no distant day. The shores of the Harlem are nearly parallel, the stream resembling, in some respects, and being actually in part, a canal. The water is already so overburdened with sewage that no system of diffusion or other partial remedy is capable of sufficiently improving it. There is not room on the drainage area of the Harlem for purification works capable of sufficiently improving the sewage to permit of its discharge into these waters, and consequently the sewage must be taken elsewhere.

The shore lines on both sides of the Upper East river are markedly irregular; the water surface being characterized by a series of large, shallow bays along the whole length, separated by long, narrow points of land.

The water in the main channel which flows through the Upper East river is not now overburdened with sewage, nor is it likely soon to become so. It has a large capacity for assimilating sewage provided the sewage is properly treated and then discharged directly at the bottom of the tidal stream.

The parts of this territory which present difficulties to main drainage are chiefly flat, low-lying valleys which extend long distances inland from the shallow bays of the river.

Except in the closely built-up part of this division, which is, or will be, tributary to the Harlem river, the population in the territory included in this report is chiefly of a semi-rural residential character, located in numerous growing villages not largely devoted to manufacturing. The future of this division seems to lie in its more complete occupation for residential purposes. The configuration of the shore, the shallowness of the water, except in the main channels, and the distance from the metropolitan centers of commercial activity are opposed to the extensive development of this section for the uses of manufacturing and transportation.

Bathing beaches, camps and other provisions for recreation at moderate expense during the summer months are now more or less numerous and seem destined to increase in popularity unless the pollution of the harbor water should become so great as to be too objectionable.

Formerly shellfish of excellent quality were gathered in large numbers in the Upper East river, and even at the present time hard-shelled clams are dredged near where the river joins Long Island Sound. Except for small boats, yachting, which was, and is, enjoyed by many persons in the Upper East river, has, for the most part sought Long Island Sound for the clearer water, lesser tidal currents and greater freedom from traffic which there prevail.

3 Separation of the Division Into Five Parts for Main Drainage Purposes.

To facilitate the sewerage and drainage of the Upper East river and Harlem division the entire territory has been separated in this report into five sub-divisions.

In each sub-division the sewage is to be collected to a central point for treatment and discharge. The boundaries of the five sub-divisions follow:

1. The Harlem Sub-division comprises the land in the Borough of Manhattan, north of 82d Street, naturally draining to the Harlem river, and that part of the Borough of the Bronx lying west of the Bronx river, except a narrow strip draining to the Hudson river.

2. The Eastern Bronx Sub-division comprises that part of the Borough of the Bronx which lies east of the Bronx river. Westchester, Unionport and Van Nest are situated within this area.

3. The Northwestern Queens Sub-division comprises the northwestern part of the Borough of Queens, draining mostly to Bowery bay and to the westerly shore of Flushing bay, and includes North Beach, Woodside, Steinway and a part of Corona.

4. The Corona-Flushing Sub-division comprises that portion of the Borough of Queens, tributary to the East river, which extends from the southeastern boundary of sub-division 3 southerly to the main divide of Long Island and easterly to a line running through Whitestone and Ingleside. Most of this area lies in the Flushing creek drainage basin. Winfield, Elmhurst, Corona, Flushing and College Point and parts of Whitestone are situated within its limits.

5. The Northwestern Queens Sub-division comprises that part of the Borough of Queens, tributary to the East river and Little Neck bay, which lies east of the limits of sub-division 4. Douglaston, Bayside and parts of Whitestone are included in this area.

Points for Concentration and Discharge of the Sewage.

The sewage will be collected to as many points as there are sub-divisions.

The sewage of the Harlem Sub-division is to be carried to Ward's Island, where it is to be treated and the effluent discharged into the swift currents of Hell Gate.

4 The sewage of the Eastern Bronx Sub-division will be collected near Clason Point, where, after treatment, it will be discharged into the deep water of the Upper East river.

The sewage of the Northwestern Queens Sub-division will be carried to a point in the neighborhood of Hell Gate and there discharged.

The sewage of the Corona Flushing Sub-division will be brought to Tallman Island, where treatment works can be located. The sewage will be discharged into the East river under conditions favorable for diffusion.

The sewage of the Northeastern Queens Sub-division will be carried to Cryder's Point, just west of Little bay and opposite Throgs Neck. There the sewage can be discharged into deep water at the extreme east end of the East river.

Methods of Treatment.

NOTE.—The methods which are proposed in this report for treating the sewage are such as have been thoroughly tested and found by the experience of many cities to give good results, while not designed to afford a high degree of purification, the processes are among the most reliable, least offensive and most economically known, and are believed to be capable of removing the impurities of the sewage to such an extent as to permit of the effluent being discharged into the harbor under suitable conditions without offense.

Eventually the growth of population and the consequent increase in the quantity of sewage produced probably will require that more complete methods of treatment shall be employed, or that the sewage shall be taken to some other place for disposal. It is impossible to foretell with accuracy when that time will arrive, but the Commission is of opinion that the works now planned will afford all the protection which the harbor will require for the next forty years, or until about 1952. As to the methods of treatment which ultimately will be needed, it is equally difficult to prophesy; the art of sewage purification has by no means reached perfection, and if the progress of the next forty years equals the accomplishments of the last twenty, a not unreasonable anticipation, marked improvements may be expected in the efficiency, economy and reliability of existing methods, if not the introduction of new processes, which will be revolutionary in character.

The probability that it ultimately will be necessary to protect the harbor against sewage to a greater extent than the requirements of the present or discoverable future require has been clearly recognized by this Commission from the first and has been kept in mind in making the plans here proposed with the object that these works might form part of a more comprehensive scheme of dealing with the sewage when that becomes necessary.

Methods of Treatment Proposed.—After a careful study of the question of the form of treatment required for the sewage of the Upper East river and Harlem Division, due regard being had to the needs of each of the five outlets, the conclusion has been reached

that fine screening or coarse screening and sedimentation will, for some years, give an effluent of satisfactory character for discharge into the water of the East river.

Where sedimentation tanks are to be used, coarse screens will be employed to protect the pumping machinery and to keep large floating matters from causing trouble in the tanks and from passing out through the outfall.

5 In all cases grit chambers will be placed on the lines of the main trunk sewers at or near the treatment works. In these chambers the sewage will be given a settling period of from one to two minutes, the velocity being reduced sufficiently to allow the heavy mineral detritus borne by the sewage to be deposited, but not enough to permit much organic matter to settle.

The grit chambers will afford protection to the pumps and will keep the proposed long and deep outfall pipes clear of gritty deposits wherever sedimentation tanks are not used. Where sedimentation tanks are planned, the grit chambers will first rid the sewage of suspended matter of a kind which would cause trouble and be difficult to handle if allowed to settle in the tanks. Grit chambers are specially useful where combined sewers are intercepted or form a part of the collecting system, as will largely be the case with the main drainage systems as here proposed for New York City.

The treatment works at Ward's Island, Clason Point and Tallman Island, for the Harlem, Eastern Bronx and Corona-Flushing Subdivisions, respectively, should consist of grit chambers, coarse screens and settling tanks. Fine screens and grit chambers at the foot of Winthrop Avenue, Long Island City, will suffice for the treatment of the sewage for the Northwestern Queens Sub-division; the sewage from the Northeastern Queens Sub-division should be passed through grit chambers and fine screens at Cryder's Point, Beechurst.

If it were deemed necessary to purify the sewage from the Harlem Sub-division to a greater extent than would be done by sedimentation or chemical precipitation, it is doubtful if its further purification could undertaken either at Ward's Island or at any other place in the vicinity. The area of land required for percolating filters, to treat the large volume of sewage which is to be brought to Ward's Island, would require more land than is available, and the odors which might be produced by their use would be objectionable in this location.

The amount of sewage to be discharged from Queens into the East river at Winthrop Avenue, although large in the distant future, will, for many years, be considerably less than the quantity brought to Tallman Island. It will never be more than a small proportion of the amount to be discharged into the river from the Ward's Island sedimentation plant, only a few hundred feet distant from Winthrop Avenue. In view of this fact, screening is the only form of treatment deemed necessary for the sewage of the Northwestern Queens Sub-division. If a more thorough treatment be needed in the future, when the volume of sewage becomes greater, it will be possible to carry the sewage by means of a tunnel under the East river to the disposal works at Ward's Island; or the necessary land

for a pumping station and settling tanks may be procured in the Borough of Queens.

6 The amount of sewage to be discharged at Cryder's Point probably will always be comparatively small and the opportunity for its diffusion and digestion in the waters of the East river is favorable; therefore screening is the only treatment required for the sewage of the Northeastern Queens Sub-division.

Sites for Treatment of Works.

Harlem Sub-division.—After considering many projects for the collection and disposal of the sewage of this sub-division it becomes evident that it would be uneconomical to take the sewage further from Hell Gate, provided a suitable site for treatment works could be found in that vicinity.

For a time it seemed likely that Riker's Island might offer every necessary facility for the disposal of the sewage, not only of the Harlem, but of most of the other sub-divisions. The area of Riker's Island is large enough for any works which might be needed, the situation is remote from inhabitated shores and the island, as yet but little occupied, already belongs to the City.

Upon investigation, Riker's Island was found to be unsuitable as a site for sewage disposal works. Composed of uncompacted refuse from New York City, the stability of the island is too uncertain to warrant the construction of the extensive engineering works required, and large sums of money would have to be spent for grading in order to save the excessive cost of pumping the large volume of sewage to the present level of the island.

The island known as Sunken Meadow was examined, but was found to require too much improvement to warrant its use as a location for sewage disposal works.

A better and a satisfactory location for the works required lies at the northeast corner of Ward's Island. This island is more favorably located than Riker's Island in respect to the economical collection of the sewage, and the land at the proposed site is low, firm and of sufficient extent for such works as will be required. The island belongs to the City of New York and is partly occupied by public institutions. No injury would be done by employing the corner selected for treatment works. Deep water lies close to the island; the shore is smooth and the currents are swift. The opportunities for an immediate diffusion of the sewage in the water are perhaps better at this place than at any other point in the whole metropolitan district, owing to the mixing action of the currents.

Eastern Bronx Sub-division.—Two large areas of marsh land, southwest and southeast of Unionport, were at first considered as sites for sewage disposal works, each being of ample size, but both situated far from deep water. A more favorable site for the location of

7 such disposal works as will be needed for this sub-division exists near Clason Point, where the ground is low and firm, and the deep and swift currents of the main channel of the Upper East river pass near the shore. A large part of the sewage from this sub-division will be brought to Clason Point by the drainage system now

under construction, and the remainder can be collected at low cost.

Northwestern Queens Sub-division.—Most of the land in the Northwestern Queens Sub-division drains naturally to Flushing and Bowery bays, but owing to the shallow water and absence of currents capable of mixing with the sewage and carrying it away, there is no point in either bay where large quantities of treated sewage should be discharged. The nearest suitable point for the discharge of the sewage, after the removal of the suspended matter, is Hell Gate, near the foot of Winthrop Avenue, and directly opposite the proposed Ward's Island treatment works. The volume of sewage to reach this place probably will be small for many years, and such land as is needed for the simple treatment required can be procured without great difficulty or expense.

Corona-Flushing Sub-division.—A large proportion of the sewage of the Corona-Flushing Sub-division can easily be concentrated near the mouth of Flushing creek and the rest can be collected by a sewer running from that point to Tallman Island, where treatment works should be located.

Tallman Island is the nearest point to the mouth of Flushing creek at which treatment works, of a kind requiring the discharge of the effluent into deep water and swift currents, can satisfactorily be placed. Both land and water conditions are suitable at this point for the location of disposal works and the discharge of the effluent. The site is practically devoid of improvement and little or no injury will be caused to future development by such works as are proposed. Deep water exists at a short distance from shore, and the volume and character of water flowing past this point are favorable for the digestion of a large quantity of sewage.

The comparative ease with which the sewage from that part of the Flushing Creek Sub-division which lies west of the creek, can be united with that from the neighborhood of Flushing and brought to Tallman Island, makes it desirable that such disposition of the sewage should be made. The sewage should not be carried to Hell Gate, for this would be more expensive and increase the burden which the water of the East river has to bear near the densely populated districts of the city.

8 Northeastern Queens Sub-division.—The only practicable place for the discharge of the sewage of the Northeastern Queens Sub-division, unless intensive treatment be employed, is the East river, between Whitestone Point and Cryder's Point. The latter is the more suitable place both for the collection and the discharge of the sewage. The East river offers better opportunities for the reception of sewage off Cryder's Point than it offers at Tallman Island or Clason Point. As the amount of sewage will probably be comparatively small, for at least a great many years, and the conditions for the digestion of the discharged sewage by the water are favorable, fine screening is the only treatment deemed necessary at this point. There should be no objection to the presence of a screening plant, provided the appearance of the building conforms with the surrounding development.

Instead of carrying the sewage of Bayside and Douglaston to Cryder's Point, as is here proposed, it is possible to treat it on per-

colating filters which can be built on the marshes near Alley creek, but as these might be objectionable to the residents of the neighborhood, the plan is not considered advisable.

Outlets.

Location and Depth.—The sewage will be discharged in every case at a distance from the shore, the position of the outfall depending upon the nearest point at which water of suitable depth can be found. It is proposed always to have the sewage discharged at depths of from 30 to 50 feet, and in such manner as to give a favorable opportunity for its admixture with the water of the river. In order to facilitate diffusion, it will be desirable to discharge the sewage from each point at more than one outlet.

Systems of Main Drainage.

Character of Sewers Proposed.—The main collecting and intercepting sewers, as planned by the commission for the Harlem, Eastern Bronx and Northwestern Queens Sub-division, will carry only the dry-weather flow of the contributing combined sewers, already built or to be built, in these districts. They are not designed to carry any portion of the storm flow. Overflows from these main dry weather sewers will allow the storm water to pass directly to the water courses. The commission does not believe that, in this district at least, the advantage gained by the treatment of the storm water, at the works proposed would warrant the extra expense involved in that procedure.

9 The main collecting and intercepting sewers, planned by the commission for the Corona-Flushing and Northeastern Queens Sub-divisions, will carry only house sewage. In these areas it is especially desirable that all new sewers be built on the separate system. Throughout this territory, few sewers of any kind have as yet been built. Practically the only combined sewers are in the villages of Flushing, Ingleside, College Point and Whitestone. The commission's plans and estimates for main drainage systems in those two sub-divisions have been made so as to utilize the existing sewers as far as practicable, and on the assumption that the dry weather flow from the existing combined sewers would be intercepted but that all sewers hereafter built tributary to these systems would carry only house sewage.

Relative Merits of Separate and Combined Sewers.—Although this commission is aware that the Board of Estimate and Apportionment of the City has approved preliminary drainage plans prepared by the Sewer Bureau of Queens Borough for a large portion of the Corona-Flushing Sub-division, and that these plans call for combined sewers, except in the low lands where the street grades to be established make combined sewers impracticable, discharging into Bowery bay all the sewage originating west of Flushing creek, the commission believes it to be desirable to provide more protection than these plans afford for keeping the waters free from sewage.

In the judgment of the commission, the character of the territory and of the neighboring waters make separate, instead of combined, sewers generally advisable for the Corona-Flushing and Northeastern

Queens Sub-divisions. Although the growth of population in many parts of this large area has been rapid, and with the extension and betterment of transit facilities is likely to be still more rapid in future, the total population at present is relatively small, and most of it is gathered into a number of more or less isolated residental communities. Large areas of unoccupied land exist. Notwithstanding the probable increase in poulation, the several communities may be expected to preserve their separate identities for many years. In these villages there probably will be only comparatively few parts which, in the near future, will support a dense population. Only small portions of the territory will need complete systems of drains for the removal of storm water. If the house sewage is removed by means of separate sewers, these can be of small size in comparison with those that would be necessary in case storm water were also to be provided for in the same system, whereas the surface water may, in many cases, be discharged into near-by water courses, such as Flushing creek, without harmful consequences. Separate sewers can thus be made to save for the present the cost of constructing the large and long storm water drains that will be necessary when the land around these creeks is fully developed. The construction of some of these long main drains can be undertaken gradually, as the need for them becomes evident through the development of the territory.

Practically all the unsewered communities in the Corona-Flushing Sub-division are in need of sewers for the removal of household wastes. But if the house sewage from these comparatively small and isolated centers of population were to be collected and carried away in combined sewers enough to take care of the storm water drainage of the districts when they shall have become densely built up in the future, not only will the present per capita cost of construction be unnecessarily high, but also the small dry weather flow in the large sewers will cause deposits to form on their bottoms, give rise to septic conditions and make a high cost for maintenance.

It would be inadvisable to recommend the installation of separate sewers in the Harlem Sub-division, as the population is practically all served at present by combined sewers, and future extensions of the same character have been planned to such an extent as to make a recommendation to this effect unwise.

In the Eastern Bronx Sub-division, also, the installation of separate sewers would not be warranted, as much of the drainage system is already under construction, and comparatively little additional work is necessary in order to bring all the sewage of the district to Clason Point.

Although the separate system would be well adapted to such a development of the land as may be expected in the Northwestern Queens Sub-division for many years, and would also serve better to protect Bowery bay from pollution during periods of storm, certain considerations make the separate system inadvisable in this territory. The treatment which is projected for the sewage in the near future is passage through grit chambers and screens. At some future time many parts of this territory are likely to be occupied by a rather dense population. Moreover, preliminary plans, contemplating the installation of combined sewers, have already been made by the

Bureau of Sewers of the Borough of Queens and approved by the Board of Estimate and Apportionment.

Collecting Sewers for the Harlem Sub-division.—The sewage of the Harlem Sub-division will be collected at Ward's Island by means of intercepting sewers which will follows both banks of the Harlem river and the north shore of the Upper East river west of the Bronx river, and connect with Ward's Island by means of tunnels.

The sewage of that portion of Manhattan which drains to the Harlem river between 82d Street and 162d Street will be collected
11 at a point in Thomas Jefferson Park just south of the corner of Pleasant Avenue and 114th Street. The south intercepting sewer will run from 86th Street and East End Avenue northerly to its junction with the north intercepting sewer in Thomas Jefferson Park. In this park, near the water-front, the sewage from both of the interceptors will be passed through grit chambers and coarse screens, and will then be carried to Ward's Island by means of a deep tunnel bored through solid rock.

The sewage of all that portion of the Bronx which drains to the Harlem river and the Bronx Kills will be collected by an intercepting sewer starting at 192d Street and following as closely as practicable the easterly shore of the Harlem river at the corner of 132d street and Willow Avenue. The dry weather flow from Marble Hill and the territory around Spuyten Duyvil will be brought by gravity into the existing Broadway sewer, while that from the low land west of Kingsbridge will have to be pumped into the sewer, which is to be intercepted at 192d Street.

The intercepting sewer along the Bronx shore of the Harlem river will receive also the dry weather flow from those areas in Manhattan north of 162d Street which drain to the Harlem river, with the exception of the sewage from a small district at the extreme northern end of the island which can be better served by having its dry weather flow pumped into a sewer at the corner of Seaman Avenue and Hawthorne Street, from which it would find its final outlet in the Hudson river at the foot of Dyckman Street. The sewage which is to be carried from Manhattan to the Bronx interceptor will be collected at 172nd Street and 201st Street by short intercepting sewers, passed through grit chambers and coarse screens and siphons under the Harlem river.

That portion of the Bronx west of the Bronx river which drains to the Upper East river will have its dry weather sewage flow collected by an intercepting sewer running from the vicinity of the Farragut Street sewer outlet at Hunt's Point to the corner of 132d Street and Willow Avenue.

At 132d Street and Willow Avenue, the sewage from the two Bronx intercepting sewers will be passed through grit chambers and coarse screens and then carried to Ward's Island by means of two deep tunnels of the same character as the one bringing the sewage from Manhattan to that place. It will be necessary to build only one of these tunnels in the near future.

As most of the area included in the Harlem Sub-division is either closely built up or is rapidly increasing in population, the collecting sewers have been designed by the commission to take care of the dry-weather flow that may ultimately be expected. The topography

and other conditions are such as to make adequate relief sewers expensive and difficult to construct.

12 Allowance in the estimates has been made for placing automatic regulators at the points in connection with the combined sewers, so as to control the flow into the interceptor from each sewer during period of storm. Allowance has also been made for the cost of such lateral sewers as will be necessary to bring to the main intercepting sewers the dry-weather flow from the outlets of the combined sewers. Most of the combined sewers are at such elevations that tide-gates will be required so as to prevent harbor water from entering the intercepting sewers; and tide-gates have been taken into account in estimating the cost of the project.

A pumping station will be located on Ward's Island, for the purpose of pumping all the sewage of the Harlem sub-division into the treatment tanks to be installed there. Final discharge of the clarified sewage will be through tunnels outletting into the East river opposite Ward's Island.

Collecting Sewers for the Eastern Bronx Sub-division.—The sewage from a large portion of the Eastern Bronx sub-division will be collected at Clason Point by a system of combined sewers now under construction. These combined sewers will be provided with storm-water overflows at various points along the Bronx river and Westchester creek.

In accordance with plans outlined by the Bronx Bureau of Sewers, another portion of this sub-division, lying east of Westchester creek, will be drained by a trunk sewer outletting at old Ferry Point; and the sewage of the remainder of the district, which drains to Eastchester bay, will be carried to an outlet on the south side of Throgs Neck.

A short intercepting sewer and a pumping station station will be all that is required to transfer the dry-weather flow from the Old Ferry Point sewer to the sewer which is to discharge at Clason Point. At a later period, another intercepting sewer could be constructed along the water-front from the pumping station to a point near Throgs Neck, in order to intercept the dry-weather flow from the district draining to Eastchester bay. The cost of this sewer has not been included in the estimates, as it will not be necessary to build it in the near future at least.

The sewage thus collected at Clason Point, after passing through grit chambers and coarse screens, will be pumped to treatment works located at that place, and the effluent discharged through submerged outlets into the East river.

The sewage of the district draining to Eastchester bay will be discharged untreated into deep water in the East river close to the junction of the East river with Long Island Sound. If at some future time it is thought advisiable to discontinue the discharge of raw sewage at this point, a connection can be made with the pumping station a Westchester creek, as previously mentioned; or treatment works can be installed in the vicinity of the outlet.

13 Collecting Sewers for the Northwestern Queens Sub-division.—The dry-weather flow from the Northwestern Queens Sub-division will be brought to the East river at the foot of Winthrop Avenue, Long Island City, by means of an intercepting sewer start-

ing on Ditmars Avenue north of Astoria Avenue, Corona, and running along the shores of Flushing bay and Bowery bay, passing thence through Steinway to its final outlet. The sewage will be passed through grit chambers and fine screens before being discharged.

With the street grades as now established, all the sewage of this area, with the exception of that from several small districts along the water-front, can be discharged into the East river by gravity. When these districts are developed, several small automatic pumping stations can be installed to pump the sewage into the main intercepting sewer. In order that the dry-weather flow from two large interior districts may be brought by gravity into the main interceptor, long dry-weather cut-off sewers will have to be constructed to intercept, at a considerable distance from the water front, the combined trunk sewers which are proposed for the drainage of these districts. The topography is such that these cut-off sewers can intercept the dry-weather flow from the combined lateral sewers which will connect with the main trunk sewers below the points from which the cut-off sewers start.

Preliminary drainage plans covering this territory have been prepared by the Queens Borough Bureau of Sewers and approved by the Board of Estimate and Apportionment. The plan proposed by the Commission interferes but little with any of the combined sewers proposed by the Bureau, except the main sewer along the water front, and affords a more favorable point for the discharge of the dry-weather flow. The storm water will be discharged directly into Flushing and Bowery bays. The main intercepting sewers along the shores of these two bays, as prososed by the Bureau of Sewers, becomes unnecessary. Steps have been taken by the Bureau of Sewers to build this sewer for the present only to a point on the southwesterly shore of Flushing bay, south of the outlet from Jackson Mill Pond. This sewer will continue to dispose of the storm water from the areas draining to the southwesterly shore of Flushing bay, while the dry-weather flow from the laterals discharging into it would be intercepted by the sewer proposed by this commission.

No satisfactory method of relieving the intercepting sewer for the Northwestern Queens Sub-division, at a reasonable cost, is apparent, and therefore this sewer has been designed by this commission to have sufficient capacity to provide for a dry-weather flow which is not likely to be exceeded for a great many years.

14 Collecting Sewers for the Corona-Flushing Sub-division.—The house sewage from practically the whole Corona-Flushing Sub-division will be brought to Tallman Island by a main trunk sewer which will start in Winfield and run through Elmhurst and across the marshes, south and east of Corona, to Flushing creek. The sewer will pass under the street by means of a siphon and will follow the easterly bank of the creek through Flushing. From this point the sewer will cross the marsh to College Point and continue to Tallman Island.

The sewage from the tributary areas will be brought to the main sewer by many trunk and lateral sewers. One of the more important of these branch sewers will start near Forest Park and join the main trunk sewer on the meadows not far from Strong's Causeway.

Another, joining the main sewer just after it crosses Flushing creek, will drain the Mill creek valley and provide a much needed outlet for the dry-weather flow from the existing Ingleside trunk sewer. Still another sewer, with several main branches, will drain that part of Corona which lies north of the Long Island Railroad and, after passing under Flushing creek as a siphon, will join the main sewer at the corner of Broadway and Lawrence Street, Flushing.

Most of College Point will be drained by two trunk sewers, one of which will tunnel through the hill from the foot of Fifth Avenue, while the course of the other will be along the shore, serving the westerly and northerly portions of College Point.

After considerable study, it has been found feasible, with the street grades as established, and with the main sewer at reasonable depth, to collect practically all the sewage to Tallman Island without pumping. Some of the low land near the head of Flushing creek is so far from the main trunk sewer that its sewage will have to be pumped to that sewer.

At Tallman Island the sewage, after passing through grit chambers and coarse screens, will be pumped into the treatment tanks to be installed there. The clarified effluent will be discharged into the East river through submerged outlets at a considerable distance from shore.

Favorable conditions exist for the future relief of the main trunk sewer in this sub-division. This is fortunate, as the territory is very large, the main sewer long, and the present population scattered and comparatively small. The trunk sewers which will join the main sewers, and the main sewer itself west of Elmhurst, have been designed to serve populations which are not likely to be exceeded for many years.

A future relief sewer designed to start on the Queens Boulevard at Caldwell Avenue, southeast of Elmhurst, and run in an easterly direction, relieving the main trunk sewer of practically all the sewage which will flow into it from the south between Caldwell Avenue and Mill creek. This relief sewer will cross Flushing creek near Strong's Causeway and enter a pumping station to be built near the confluence of Mill and Flushing creeks. The Mill creek valley sewer will also be diverted so as to enter the station.

From the pumping station near the junction of Mill and Flushing creeks, the sewage will be lifted into a high level relief sewer which will flow through Flushing and follow the high land west of Whitestone to the treatment works at Tallman Island. This future high level intercepting sewer will be continued, above its junction with the force main from the pumping station just mentioned, in a southerly and easterly direction through Flushing, Ingleside, and Flushing Heights. The sewage from the high land between the Mill creek valley and Cedar Grove Cemetery may be collected and siphoned across the lower end of this valley into the high-level sewer in Flushing.

The high-level relief sewers, just described, will deliver by gravity to the treatment works the sewage from practically all the high land of the Corona-Flushing Sub-division which lies east of Flushing creek.

The original main trunk sewer from Winfield to Tallman Island will be of sufficient size to carry the sewage which, for many years, may be expected to originate within the territory which will not be served in the future by the relief sewers, as described. It will be large enough, moreover, to carry the sewage from the whole Corona-Flushing Sub-division for a long time.

Collecting Sewers for the Northeastern Queens Sub-division.—The sewage from the Northern Queens Sub-division will be carried to Cryder's Point by two main intercepting sewers. One of these, the Whitestone intercepting, will start near the water west of Whitestone Point and run along the Whitestone shore and through Beechhurst to Cryder's Point. Near Whitestone Landing, a trunk sewer, draining a large inland district between Whitestone and Ingleside, will join the intercepting sewer.

The other main intercepting sewer will extend along the shores of Little bay and Little Neck bay, from Cryder's Point to a point in Bayside just north of Oakland Lake. At this place a trunk sewer will extend to the west, draining the large district between Ingleside and Bayside. At Broadway, in Bayside, the sewage from Douglaston, Little Neck, and the low land lying between Bayside and Douglaston, will be received into the main intercepting sewer through a force main which will run from an automatic, electrically-operated pumping station near Alley creek. To this pumping station the sewage from Douglaston and Little Neck will be brought by an intercepting sewer starting east of Douglas Manor and following closely the shore of Little Neck bay to the pumping station.

16 Practically all the sewage of the Northeastern Queens Sub-division, with the exception of that from Douglaston, Little Neck, and the low lands around Alley creek, can be brought to Cryder's Point, and there passed through screens and discharged into deep water by gravity. The sewage from a very small area near Whitestone Landing, and from several low-lying districts along the shore of Little bay and Little Neck bay, will have to be pumped into the high level sewers when the population on these areas becomes large enough to require sewage facilities. Also, a small marshy district near the city boundary, east of Douglas Manor, cannot be drained into the Douglaston intercepting sewer. These small districts will be served by inexpensive automatic pumping stations.

All the trunk and intercepting sewers of this sub-division, excepting the lower end of the intercepting sewer from Bayside to Cryder's Point, have been designed to serve a population which is not likely to be exceeded for many years. From Shore Avenue northward, it is proposed to relieve this sewer by a parallel sewer run-ing to Cryder's Point, but such a relief sewer will not be necessary for a long period.

Areas, Populations and Quantities of Sewage.

The following table gives, for the several sub-divisions, the areas, the estimated population and average dry-weather sewage flow upon which the design of the sewers was based, and the capacities of treatment works which the Commission has used as a basis for estimating the cost of the projects proposed for the Upper East River and Harlem Division:

Sub-division.	Area (without parks, etc.), acres.	Population.			Average dry-weather flow of sewage Mgd.		Capacity on treatment works on—	
		In 1910 from U. S. census.	In 1940 (estimated).	Which sewers are designed to serve.	In 1910.	In 1940.	Which sewers are designed to carry.	Which estimate is based Mgd.
Harlem	12,100	905,300	2,105,800	2,838,000	124.4	302.2	404.6	200
Eastern Bronx	10,600	30,300	73,000	.....	3.8	12.8	.....	20
Northwestern Queens	3,100	10,000	28,500	253,000	0.5	5.0	34.0	15
Corona-Flushing	16,800	62,200	179,800	282,400	4.0	27.5	39.0	40
Northeastern Queens	5,900	8,000	22,900	62,800	0.3	4.5	9.6	10
Totals	48,500	1,106,800	2,410,000	.....	133.0	352.0	.....	285

17 Preliminary Estimates of Cost of Main Drainage Works.

The following table gives a summary of the estimated cost of construction and of the annual charges for maintenance and operation for the works suggested in this report. The costs of land and rights of way are not included.

Sub-division.	Cost of construction, including engineering.	Cost of maintenance and operation, including fixed charges.
Harlem	$9,814,000	$701,000
Eastern Bronx	708,000	87,000
Northwestern Queens	352,000	29,000
Corona-Flushing	1,961,000	154,000
Northeastern Queens	563,000	42,000
Total	$13,398,000	$1,013,000

(Here follows map of Proposed Sewer Disposal Project for Upper East River and Harlem Division.)

a COMPLAINANT'S EXHIBIT No. 201. James D. Maher, Commissioner.

NEW YORK CITY, May 19, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York's Sewage.

V.

Study of the Collection and Disposal of the Sewage of the Richmond Division.*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.
September, 1912.

1 *Study of the Collection and Disposal of the Sewage of the Richmond Division.*

September 1, 1912.

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: This report on the collection and disposal of the sewage of the Richmond Division, is the fifth in the series of Preliminary Reports on the Disposal of New York's Sewage which has been issued by this commission with the object of making public at an early date its opinion as to the way in which it will be necessary to deal with the sewage of the Metropolitan District.

The adoption of the plans here proposed would provide the northern and northeastern parts of Staten Island, containing all the more thickly settled localities and including over eighty per cent. of the population of the borough, with main drainage and sewage disposal works at moderate cost, and would afford as great a measure of protection as a consideration of the condition of the water in the whole harbor and of the possibilities of contamination in this locality seem to make necessary.

The disposal of the sewage of that part of the Borough of Richmond not provided for in this report offers little difficulty. That part of the territory which is not rural should be provided with local

* This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

disposal plants of such high efficiency that their effluents can be discharged into the neighboring water courses without danger of causing local offense.

The possibility that a greater degree of protection for the harbor than is proposed in this report may be needed in the distant future has been borne in mind in preparing these plans and, in consequence, the works have been so devised as to be adaptable to a more comprehensive scheme without undue loss of the completed structures.

All the work planned in this report will not be required in the immediate future, but it is regarded as necessary that such main drainage work as is undertaken by the city in this borough shall conform to these plans or such modifications of them as a more detailed study of the local conditions than has been possible by this commission may require.

To a great extent the sewerage plans made by the local authorities have been utilized in preparing the plans of main drainage and disposal described in this report, the object being to aid and supplement the city's efforts in disposing of the sewage in a sanitary manner. In those localities for which the borough has had no definite sewerage plans, it has been necessary to outline the future lateral sewerage districts as seemed most reasonable from the information at hand concerning the proposed locations and grades of streets. By following the same outlines as nearly as may
2 seem best after detailed study, the engineers of the borough will be able to facilitate the final design of the main drainage systems along the lines recommended in this report.

General Description of the Territory.

Location and Area.—This report deals with that part of Staten Island which slopes toward the Narrows, Upper bay, Kill van Kull and Newark bay, or nearly the whole of the northern and northeastern portions of the Borough of Richmond. This territory includes, besides the natural drainage areas tributary to the bodies of water mentioned, a comparatively small area which drains naturally to Willowbrook, and thence to Fresh Kills and Lower New York bay, and from which it is feasible and desirable to carry the house sewage to the Kill van Kull for final disposal.

The line bounding the district on the south starts from Fort Wadsworth at the Narrows, and runs in a generally westerly direction through Arrochar and Grasmere, across Todt Hill and through the grounds of the Richmond Borough Almshouse, finally reaching the village of New Springville. On the west the boundary line follows closely the Port Richmond Road, passing through Bull's Head and Graniteville, and thence not far from Morningstar Road to a point south of Elm Park, from which point it follows the watershed along the Staten Island Rapid Transit Railroad, westerly nearly to South avenue, whence it runs in a northwesterly direction, crosses Richmond Terrace near Holland avenue, and continues to the shore of Newark bay east of Howland Hook.

Between this line and the established bulkhead line bordering the Narrows, Upper bay, the Kill van Kull and Newark bay, there is included an area of 9,178 acres, or about 14.3 square miles exclusive of cemeteries, parks, institutional property, U. S. Government land, etc. This area is approximately equal to one-fourth of the total land surface of Staten Island.

Topographical Features.—The topography of the territory is varied. The part which drains to the northeastern shore of Staten Island is separated from that which drains to the north shore by a high ridge which traverses the island in a general northeasterly and southwesterly direction, and which rises at Todt Hill, on the southern boundary of the territory, to an elevation of 409.8 feet above the Richmond high water datum. The slopes on the easterly side of the ridge, within the limits of the territory, are precipitous. The westerly and northerly slopes are generally gradual.

In the western part of the territory the land is comparatively low, and in many places, near the water courses and shores, it is
3 swampy. The slopes down to these swampy areas are generally gradual, and the ridge marking the outline of the district on the west is not high.

The terminal moraine forms a conspicuous feature of the topography in the southeastern part of the district. Along the boundary line from Arrochar to Grasmere the bare rounded hills and numerous depressions and ponds, characteristic of morainic topography, are especially noticeable.

The land near the shore, from Fort Wadsworth to Howland Hook, is made up alternately of headlands, of varying height, and valleys. Streams flow through many of these valleys, while in others the natural water courses have been replaced by sewers. Much of that portion of the territory which drains to the Kill van Kull lies within the drainage area of Bodine creek, which is the largest water course in the district.

Population.—Nearly all the more thickly settled part of Staten Island lies within the drainage districts of the Narrows, Upper bay, Kill van Kull and Newark bay. Out of a total population in the Borough of Richmond, in 1910, of 85,969, this territory contained an estimated population of 64,320, or almost exactly three-fourths of the total. In 1940, it is probable that this area will have no less than 140,000 people out of 190,000, the minimum number that may be expected in inhabit the borough at that date.

While, for a number of years previous to 1905, the growth of population in the borough was slow, due to various causes, since that date the population has increased at a comparatively rapid rate. Owing to changed conditions, it seems reasonable to expect that this rapid growth will continue.

Development.—The land which lies near the shore from Rosebank almost to Howland Hook is well populated, and in some places thickly settled, but no part of the whole area has a population closely approaching in density that which exists in most of the other boroughs of New York City. In fact, with the exception of a few centers which are chiefly devoted to business purposes, and a number

of spots where buildings of a poor class are huddled together, the whole area, for a considerable distance back from the waterfront, may be termed suburban. Further from the water, most of the territory is rural in character, and there are large tracts which are still wholly unimproved.

While the populated sections will gradually extend farther and farther from the waterfront, much of the territory to the south and southwest is likely to remain in a rural and unimproved state for many years. It seems certain that the business centers will gradually expand, although nearness to Manhattan will cause activities to be confined mostly to the establishment of stores to supply the needs of the local population. In course of time docks
4 and warehouses will undoubtedly occupy the Stapleton waterfront, and water and rail facilities make the north shore a superior place for the establishment of factories.

Sewerage of the Territory.—During the last few years, large amounts of money have been spent by the borough in the construction of sewers. In the areas which drain to the Narrows and Upper bay, and along the western part of the north shore of the island, much progress has been made in replacing old and shallow village sewers, formerly built to take care of the immediate needs for house drainage, by modern systems. Except in some of the low areas near the waterfront, these new sewers are of the combined type.

In much of New Brighton, and in West Brighton and Port Richmond, the old village sewers have so far remained more or less adequate to the needs of the communities. Few, if any, new combined sewers have been constructed, and little has yet been done concerning the preparation of drainage plans for these areas. The natural water courses which traverse those areas have proved sufficient for the removal of the storm water, and they can continue for some time to perform this service for many places. Certainly, if the storm water in the thickly settled areas near the waterfront is removed by sewers, the run-off from the more sparsely settled upland territory can be adequately provided for in the natural water courses for many years to come.

Wherever new and complete systems of sewers have been installed, the dry-weather flow has been diverted from them, above mean high tide, and carried in a pipe to moderately deep water and the outlet for the storm water has been placed near the shore line. It is the intention of the borough authorities to extend the dry-weather and storm-water outfalls to the pierhead and bulkhead lines, respectively, when the piers and bulkheads are built. By this method of discharging the house sewage into deep water, during dry weather, the shores near the sewer outlets have escaped much of the pollution which otherwise would have been inevitable. Nevertheless it is felt that, at many points, the discharge of house sewage in a crude state, even at the pierhead line, will not be permissible much longer. For this reason an experiment station has been established by means of which the most suitable method of handling the local sewage disposal problem can be studied.

Separation of the Territory into Subdivisions.

The topography of the whole division is unfavorable for the collection of all the sewage to one central point for disposal. The high ridge separating the areas draining to the northeastern shore of the island from those draining to the north shore, the small areas of low land in the western end of the division, the great distance which it would be necessary to carry much of the sewage and the amount of pumping required are opposed to the collection of the sewage at a point near the Narrows, which is the most favorable place available for its ultimate discharge.

While the discharge of all the house sewage from the northerly and northeasterly slopes of Staten Island into the Narrows would be desirable, and economy of operation would result from having only one disposal plant to maintain, it is believed that the benefits derived would not compensate sufficiently for the cost of carrying the sewage to such a plant. Moreover, it seems certain that the Kill van Kull, with its deep water and swift currents, would provide, for many years, if not for all time, a sufficiently favorable place for discharging the sewage from the areas bordering on Newark bay and the Kill van Kull, after it has been passed through settling tanks.

The territory with which this report deals has been subdivided in such a way as to facilitate the collection of the sewage, to provide for each subdivision a favorable and adequate place for treatment works, and to minimize the amount of pumping necessary. At the same time care has been taken not to divide the territory to such an extent as to cause the establishment of plants too small to be operated economically.

The subdivisions, five in number, have been given names associated with the points chosen for the sites of the respective treatment works. They are named and described as follows:

1. The Quarantine Subdivision comprises the area naturally draining to the Narrows from Fort Wadsworth to the Marine Hospital, Stapleton. The settlements known as Clifton, Rosebank and Fort Wadsworth lie within its boundaries.

2. The Stapleton Subdivision comprises the area naturally draining to the Narrows between the Marine Hospital and St. George. Tompkinsville, Stapleton and Concord lie within this area.

3. The Livingston Subdivision comprises the area naturally draining to Upper New York bay west of St. George, and most of that draining to the Kill van Kull east of a line joining the southerly end of Silver Lake, the corner of Castleton and Bement avenues, and the northerly end of Elm Court, West New Brighton. Sailors' Snug Harbor and the settlements of New Brighton and Livingston are included.

4. The West New Brighton Subdivision comprises, roughly, the area naturally draining to the Kill van Kull between the westerly limit of the Livingston subdivision and Tower Hill, Port Richmond, together with the area draining to Willow brook, east of Port Richmond Road. West New Brighton and Castleton Corners, and parts of Port Richmond, Graniteville, Bull's Head and New Springville are in this subdivision.

5. The Elm Park Subdivision comprises, roughly, the area naturally draining to the Kill van Kull and Newark bay between Tower Hill and Holland avenue. Elm Park and parts of Port Richmond and Mariner's Harbor are within its confines.

The boundaries of the Quarantine, Stapleton and western part of the Elm Park subdivisions, are fixed by the limits of the sewerage districts already outlined by the engineers of the borough; but the boundaries of the Livingston and West New Brighton subdivisions, except where bordering on the Stapleton subdivision, and of the eastern part of Elm Park subdivision, have been placed by this commission as seemed best suited to the main drainage plans to be worked out. The limits agree, however, in a general way, with sewerage districts which have been outlined, but as yet only approximately, by the engineers of the borough.

Outline of the Proposed Plan for Main Drainage.

The proposed plan for the Quarantine subdivision provides for the collection of the sewage by a high-level intercepting sewer to the foot of Nautilus street, near the Quarantine Station, where, after passing through coarse screens, grit chambers and fine screens, it will be discharged into the deep water of the Narrows. The sewage from the low land in Clifton will be pumped to the high-level sewer.

In the Stapleton subdivision, the sewage will be collected near the foot of Water street, Stapleton, by high- and low-level sewers, passed through settling tanks, and discharged into the Narrows, off Canal street.

The plan for the Livingston subdivision provides for the collection of the sewage, mostly by high-level sewers, to the waterfront at Kissel avenue, Livingston, where, after being passed through settling tanks, it will be discharged into deep water in the Kill van Kull.

According to the proposed plan, the sewage from the West New Brighton subdivision will be brought, by high- and low-level intercepting sewers, to the waterfront near the garbage incinerator in West New Brighton, passed through settling tanks, and discharged into deep water in the Kill van Kull.

7 In the Elm Park subdivision, the sewage will be collected, by high- and low-level sewers, to the vicinity of Newark avenue and Richmond Terrace, where, after being passed through settling tanks, it will be discharged into deep water in the Kill van Kull.

The sewers will vary from 8 inches to 6 feet 9 inches in diameter, and their total length will be 10.88 miles.

Main Drainage Systems.

Kind of Sewers Proposed.—The collecting and intercepting sewers, as planned for the five subdivisions, are designed primarily to carry eventually only the dry-weather flow from the contributing sewers, already built or to be built, in these subdivisions. Attention has been directed to the fact that the sewers built by the borough have

been, in general, of the combined type, and that future construction is planned along the same lines. This means that during wet weather much of the house sewage, mixed with varying volumes of storm water, will continue to the bulkhead line without being intercepted, and will there be discharged. The growth of population to be expected in the borough has so influenced the design of the proposed dry-weather trunk sewers that many of them will assist materially, for a considerable period, in the disposal of the storm water.

While it would be inadvisable, in those districts that have already been sewered by the borough authorities, to provide systems of separate sewers, using those already built to remove storm water, this commission considers it desirable, from now on, to construct sewers on the separate plan, and provide only such storm-water sewers as are demanded from time to time. Relieved of an admixture of house sewage, it is likely that many of these storm sewers might empty directly, for many years to come, into the natural water courses which flow northerly into the Kill van Kull. The building of the comparatively small sewers required for the house drainage, and only such storm-water sewers as are absolutely needed, would minimize the cost of sewer construction, a consideration of much weight, especially in view of the fact that the population which can be assessed is small. Among other advantages which the separate system would possess may be mentioned better protection against pollution to the water near shore during wet weather and less quantity of sewage to be handled in the treatment works.

The plans here proposed have been worked out on the assumption that the present policy of constructing combined sewers will be continued, but whether or not this policy is followed in the areas to be sewered in future, the principal features of the main
8 drainage systems and of the treatment works would be the same. If the sewers were built on the separate system, however, connecting chambers, overflows, tide-gates, and perhaps grit chambers, would be unnecessary, and the costs would be reduced to that extent.

Population and Quantity of Sewage.—The sizes to be provided for the main trunk sewers for collecting the dry-weather flow in localities similar in position and condition to the settlements on the northern and northeastern shores of Staten Island should not depend, as has been the case in many cities, upon an estimate of population at any definite period, but upon densities of population on the tributary drainage areas which are considered probable when the areas shall have reached approximately their ultimate development.

The part of Staten Island included within this division is so near Manhattan, and there are so many other reasons, including the possibility of rapid transit, which may greatly accelerate the growth of population in any part of or throughout the district that it would be unwise to restrict the capacities of the proposed trunk sewers to suit what now appears to be the needs of the district thirty years hence. The total construction cost of the sewers as designed will not be a very large sum, and the saving effected by cutting down

their capacities materially would not be as great as might be supposed.

In order to estimate the necessary capacities of treatment works, pumping equipment and other parts of the main drainage works that can easily be added to at later periods, it is essential that estimates be made of present populations and sewage flows. The following table presents these figures as estimated for the various subdivisions for the year 1910, based on United States Census figures. The areas of the subdivisions are calculated to the established bulkhead line, but do not include cemeteries, parks, Sailors' Snug Harbor, U. S. Government property, etc. The "area sewered" column of the table has no reference to the actual area in each subdivision that was provided with sewers in 1910, but the figures represent roughly the areas that were fairly well settled and might with reason be provided with sewers. The populations estimated for these sewered areas are the ones which have been used as a basis for estimating the flow of house sewage. It will be noticed that in the low-level areas the whole population was assumed to be served by sewers. The total sewage flow, manifestly, is not the average daily amount of sewage that was discharged from the sewer outlets of the district during dry weather, in 1910, but the figures represent a rough estimate of the average amount that might have been expected under a more complete development of the sewerage systems.

Here, as throughout this report, the average flow of house sewage has been assumed to be 125 gallons per inhabitant per day,
9 and the average ground-water leakage has been taken at 500,000 gallons per square mile per day, irrespective of local conditions.

Population and Sewage Flow of the Five Sub-divisions in 1910.

1.—High Level Territory.

Sub-division.	Area, acres.	Area sewered, acres.	Population.	Population on sewered area.	House sewage, mgd.*	Ground water leakage, mgd.*	Total sewage flow, mgd.*
Quarantine	661	330	6,057	5,500	0.69	0.26	0.95
Stapleton	1,532	600	16,152	15,000	1.40	0.47	1.87
Livingston	893	600	11,183	10,000	0.93	0.47	1.40
W. New Brighton	4,735	600	12,400	10,000	0.93	0.47	1.40
Elm Park	173	140	3,589	3,500	0.33	0.11	0.44
Totals	7,994	2,270	49,381	44,000	4.10	1.78	5.86

* Million gallons per day of 24 hours.

2.—High Level Territory.

Quarantine	156	80	1,404	1,404	0.13	0.06	0.19
Stapleton	182	110	3,241	3,241	0.30	0.09	0.39
Livingston	66	35	250	250	0.03	0.03	0.06
W. New Brighton	321	240	5,082	5,082	0.47	0.19	0.66
Elm Park	459	280	4,962	4,962	0.46	0.22	0.68
Totals	1,184	745	14,939	14,939	1.39	0.59	1.98

Total Population and Sewage Flow of the Five Sub-divisions in 1910.

Sub-division	Area, acres.	Area sewered, acres.	Population.	Population on sewered area.	House sewage mgd.*	Ground water leakage mgd.*	Total sewage flow mgd.*
Quarantine	817	410	7,461	6,904	0.64	0.32	0.96
Stapleton	1,714	710	19,393	18,241	1.70	0.56	2.26
Livingston	959	635	11,433	10,250	0.96	0.50	1.46
W. New Brighton...	5,056	840	17,491	15,082	1.40	0.66	2.06
Elm Park.....	632	420	8,542	8,462	0.79	0.33	1.12
Totals.....	9,178	3,015	64,320	58,939	5.49	2.37	7.86

* Million gallons per day of 24 hours.

10 The following table gives the densities of population, total population and average sewage flow used in designing the sewers of each subdivision. All the territory is assumed to be sewered. The area as far as the bulkhead line has been assumed to be populated. Much of the ground near the water will be occupied by industrial establishments instead of dwellings, but sufficient allowance for the sewage flow from these has probably been made by assuming the area populated throughout.

Total Population and Sewage Flow used in Designing the Proposed Sewers.

Sub-division.	Density of population per acre.	Population			Aver. sewage flow mgd.*		
		High level.	Low level.	Total.	High level	Low level.	Total.
Quarantine	75 –100	52,870	15,600	68,470	7.12	2.08	9.20
Stapleton	70†–150	112,385	19,870	132,255	15.24	2.63	17.87
Livingston	75 –100	81,975	6,600	88,575	10.94	0.88	11.82
W. New Brighton.	40‡–120	247,960	38,260	286,220	34.69	5.04	39.73
Elm Park.....	80 –120	18,040	40,060	58,100	2.39	5.37	7.76
Whole District....	40 –150	513,230	120,390	633,620	70.38	16.00	86.38

* Million gallons per day of 24 hours.
† Average density on 1,116 acres.
‡ Average density on 1,814 acres. Average density of 50 on 1,283 acres.

Collecting Sewers for the Quarantine Subdivision.—Most of the sewage of the Quarantine subdivision will be collected at the foot of Nautilus street by a high-level intercepting sewer which will intercept the dry-weather flow from the combined sewer in Maple avenue at the corner of Anderson street and pass through Anderson street, Chestnut avenue, New York avenue, Sylvaton terrace and Bay street, and along the shore to Nautilus street. On its route, it will receive the flow from all the territory lying south and west of its course.

The sewage from the low land in Clifton will be collected at the corner of Bay street and Maple avenue by an intercepting sewer in Bay street which will intercept the dry-weather flow from existing sewers in Norwood avenue and Simonson avenue. At Bay street the dry-weather flow from the Maple avenue sewer will be diverted, and together with the flow from the Bay street intercepting sewer will be

led into an automatic, electrically-operated pumping station to be located at this corner. From this pumping station, the sewage will be pumped through a force main in Bay street to the high-level intercepting sewer at the corner of Bay street and Sylvaton terrace.

11 The dry-weather flow from the existing Nautilus street sewer, which drains a large area, will be intercepted and carried by a short connecting sewer to a junction with the high-level sewer above mentioned. The plan also contemplates the construction of a small high-level sewer in Centre street which will intercept the dry-weather flow from the combined sewer at the corner of Norwood avenue and discharge it at Simpson avenue, or a short distance north of it, into the combined sewer planned for Centre street. It will thence be carried to the Maple avenue sewer and finally into the high-level sewers in Anderson street.

The proposed collecting sewers in the Quarantine subdivision vary from 12 inches to 3 feet 3 inches in diameter. Their total length, including the force main, but exclusive of the outlet pipe, is 1.46 miles.

Collecting Sewers for the Stapleton Subdivision.—A large part of the area included within the Stapleton subdivision is at a sufficient elevation to permit its sewage to be collected and passed by gravity through tanks located at Stapleton, but the elevations of the streets in the vicinity of the works are so slight that the sewage from the high-level districts will have to be carried to the works in long conduits submerged below the hydraulic gradient.

On the north, the dry-weather flow from the Arietta street sewer will be intercepted at Stuyvesant place and brought, together with sewage collected on its route, by a high-level sewer passing through Stuyvesant place, Griffin, Hannah, Sarah Ann, Van Duzer and Elizabeth streets to a point a short distance east of Van Duzer street, from which place it will be carried to the treatment works, located on Front street between Prospect street and Water street, by a siphon passing through Elizabeth street, rights of way and Front street.

On the south, the dry-weather flow from the large sewer in Board street will be intercepted at the corner of Canal and Board streets and carried to the treatment works by a siphon passing through Canal, Water and Front streets. From the corner of Riker and Broad streets, a connection will be laid in such a way as to join the large Broad street sewer just above the point at which its dry-weather flow is intercepted.

At Wright and Beach streets, this siphon will have connections through which the dry-weather flow from the existing sewers in these streets will be added. Ample head for this purpose can be secured without making these cutoff sewers of great length.

That part of the sewage of the subdivision which cannot be passed through the treatment works by gravity will be brought to an automatic, electrically-operated pumping station located at the works. Here the sewage will be raised by the pumps to such an elevation as to allow it to pass through the tanks.

12 The two low-level intercepting sewers required will be built in Front street and will be short. The one from the north

will start, until its extension is required, by intercepting the dry-weather flow from the existing Elizabeth street sewer: the one from the south will intercept the dry-weather flow outlet sewer at present in Canal street, and will be joined by the existing 15-inch sewer in Water street. It is assumed that the 10-inch sewer in Thompson street, which now creates foul conditions by discharging into the dock, will be joined to the sewer in Canal street and the flow thus taken to the treatment works.

In designing the high level siphons, the available head was found so small that the velocities through the siphons would have to be less than desirable. They would be especially small for a number of years. Trouble from this cause can be obviated by constructing by-passes from these siphons to the suction well of the pumping station at the treatment works. By means of these by-passes, the siphons can be easily and effectively flushed.

It was found best to make the south siphon of a capacity sufficient to take care of the needs for only a few years with the idea that one or two more conduits can be constructed as required. With the north siphon, conditions were somewhat different. It will be economical to provide this siphon with the same capacity as that of the intercepting sewer leading to it. In order to make the velocity of sewage as great as possible when the flow is small, the north siphon will consist of two pipes of different sizes, the larger one to come into use automatically when the level of the sewage in the high-level sewer reaches a certain height.

Both the north siphon, of 24-inch and 18-inch pipes, and the south siphon, of 24-inch pipe, could it is thought, be built economically and properly of vitrified pipe, with bituminous joints and surrounded by concrete, and the estimates have been based upon this type of construction.

The proposed collecting sewers in the Stapleton subdivision vary from 15 inches to 2 feet 9 inches in diameter. Their total length, including siphons, but exclusive of outlet pipe, is 1.54 miles.

Collecting Sewers for the Livingston Subdivision.—Practically all the sewage of the Livingston subdivision can be brought to the treatment works at the foot of Kissel avenue and passed through them by gravity.

The sewage from St. George and New Brighton will be collected by a high-level intercepting sewer which will start at the corner of Jay and Wall streets and pass through Jay street and Richmond terrace to the treatment works.

From the south a high-level sewer will start at the corner of Kissel avenue and Brighton boulevard and pass through Kissel and
13 Bergen avenues and Health place to the treatment works.

A branch of this sewer will be constructed in Bergen avenue between Oakland avenue and Health place.

A small low-level intercepting sewer will be built in Richmond terrace from Oakland avenue to a small, automatic, electrically-operated pumping station located at the site of the treatment works.

In this subdivision the high-level sewers will have to pass through low land before reaching the treatment works. The street grades

in these low areas have been at least tentatively established. However, the area is not yet built up and it will be feasible to raise the projected street grades wherever necessary, so as to give a light, but sufficient cover over the top of the sewers.

The proposed collecting sewers in the Livingston subdivision vary from 10 inches to 3 feet 3 inches in diameter. Their total length, exclusive of outlet pipe, is 2.77 miles.

Collecting Sewers for the West New Brighton Subdivision.—The sewage of the West New Brighton subdivision will be collected by two high-level and two low-level sewers. Just before reaching the treatment works, which are to be located south of Starin avenue, between Bodine and Dongan streets, the sewers join so as to form one high-level and one low-level sewer.

The east high-level intercepting sewer will start at the corner of Elm court and Henderson avenue and pass through Henderson avenue, Water street and Richmond terrace to a junction with the west high-level intercepting sewer.

The west, or perhaps better, the south-high-level intercepting sewer, has been assumed, for the purposes of this report, to start at the proposed Northfield boulevard. Its route will be through Linnet street, Madison avenue, Jewett avenue, Roberts street, Manor road, Castleton and Columbia avenues, Cedar and Bodine streets and Richmond terrace, and thence through the city's property at the West Brighton garbage incinerator. A small branch of this sewer will be built in Palmer avenue east from Heberton avenue, so as to intercept the sewage flow from the high area west of the latter street.

The east low-level intercepting sewer will start at the foot of Broadway, at which point it is assumed that the flow from the combined sewers in the low area in the vicinity will collect, and will pass through Richmond terrace and Starin avenue to Dongan street, where it will join with the west low-level intercepting sewer.

The sewage from a large part of Port Richmond and the low area in the vicinity of Bodine creek and Palmer's run will be brought to an automatic, electrically-operated pumping station at the treatment works by the west low-level intercepting sewer which
14 will start in Richmond avenue north of Richmond terrace and pass through Richmond terrace, Starin avenue and Dongan street.

Whether the large undeveloped areas in the West New Brighton subdivision, which lie south of the proposed Northfield boulevard, are finally sewered upon the separate or upon the combined plan, all the dry-weather sewage flow can be brought by gravity to the upper end of the west high-level intercepting sewer as proposed.

On account of the large population which eventually will occupy the extensive area tributary to it, this sewer is much larger than any of the collecting sewers in the other subdivisions, and can serve for many years to carry to the waterfront much of the storm-water brought to it by the combined sewers in West New Brighton. The surplus storm-water would be led to a trunk sewer which would also collect the flow from the sewers of the low-level district. It is suggested that this trunk sewer be designed of a size sufficient to care for the ultimate

dry-weather flow of the low-level district tributary to it, together with only such storm water as it would probably have to carry for a few years, with the idea that later, when it becomes necessary to close up the water courses and provide artificial channels for the storm-water from the large and now undeveloped areas, a large storm-water sewer can be built to the waterfront.

The conditions in much of this subdivision, with its numerous open water-courses, are such that great economy would result from the construction of sewers on the separate system. It will be particularly desirable, when the time arrives, to sewer on the separate system that portion of this subdivision which lies south of Richmond turnpike and drains directly to Willow brook. When it becomes no longer possible to provide for the storm-water from this area on the surface, it should be emptied into Fresh Kills instead of being carried with the house sewage all the way to the Kill van Kull.

In all the subdivisions, it has been assumed that streets would be opened and graded according to the plans at present outlined by the borough. In this subdivision particularly, the routes of many of the proposed sewers are laid out in streets which are not yet opened.

Owing to topographical conditions in the different subdivisions, the high-level sewers, near their entrance to the various treatment works, have had to be placed lower with reference to the ordinary sewage level in the settling tanks than is desirable. With the small amount of sewage that will be carried through these sewers in dry weather for some time after their construction, small velocities will occur in their lower ends. This will cause trouble from deposits only for a short distance, if at all, in any of the sewers except the west high-level sewer of the West New Brighton subdivision, as all of
15 them except the one named are small in size and their grades are considerable. While the dry-weather flow is small it might be practicable to run the tanks with a somewhat lower sewage level than that for which they are designed. Opportunity for creating a greater velocity at intervals might be afforded by a temporary lowering of the water level in the tanks or by providing a by-pass to the pumping stations, outfall pipes, or to storm or combined sewers at a lower level.

The proposed collecting sewers in the West New Brighton subdivision vary from 8 inches to 6 feet 9 inches in diameter. Their total length, exclusive of the outlet pipe, is 3.14 miles.

Collecting Sewers for the Elm Park Subdivision.—In the four subdivisions already considered, it has been found practicable to collect and dispose of most of the sewage by gravity. Conditions in the Elm Park subdivision are different, resulting in the necessity of pumping considerably more than half the sewage.

A high-level intercepting sewer will start at the corner of Lafayette avenue and Harrison avenue, Port Richmond, to which point it is assumed that a combined sewer in Elizabeth street and Harrison avenue will bring sewage from points as far east as Broadway. The route of the high level sewer will be through Harrison, Nicholas and Charles avenues, Douglas street and Newark avenue to the treatment works at the corner of Newark avenue and Richmond terrace.

A short branch of this sewer in Roselle and Monroe streets, as far as the railroad, will bring to it the dry-weather flow from existing sewers in Monroe and Cedar streets.

From the east, the sewage from the low-level district will be brought to an automatic, electrically-operated pumping station at the treatment works by a sewer in Richmond terrace starting at Nicholas avenue. From the west, the sewage will be carried to the pumping station by a sewer in Richmond terrace. This sewer will intercept the dry-weather flow from the existing combined trunk sewers in Harbor road, Union avenue and Housman avenue.

The proposed collecting sewers in the Elm Park subdivisions vary from 8 inches to 3 feet in diameter. Their total length, exclusive of the outlet pipe, is 1.97 miles.

Pumping Stations.—All the pumping stations in the division will be of the automatic, electrically-operated type. The current for operating them can be purchased, or it might be furnished by the garbage incineration plants at West New Brighton and Clifton, thus affording a desirable outlet for some of the surplus power generated at those plants. This surplus power would undoubtedly be used at the West New Brighton sewage pumping station, as there would be no expense for transmission at this point. It would also probably pay to transmit power from the Clifton incinerator to the Maple avenue pumping station in the Quarantine subdivision. Whether it would be economical to transmit power from the West New Brighton incinerator to the Elm Park and Livingston pumping stations, and from the Clifton incinerator to the Stapleton pumping station, would depend upon the price for which current could be purchased from the light and power company.

16

All the pumping equipment ultimately necessary in these stations would not be required at first. However, all pumps and motors should be in duplicate.

The following table gives the average total head pumped against, the estimated average sewage flow which would have arrived at each pumping station in 1910 under the assumptions given in the discussion of population and sewage flow, the average sewage flow at each station which was used as a basis for estimating the cost of operation, and the aggregate average sewage flow which the sewers leading to the station were designed.

Pumping station.	Total head, feet.	Average sewage flow—Mgd.*		
		Estimated for 1910.	Basis for cost of operation.	Contributing sewers designed for.
Maple Avenue....	10.0	0.19	0.50	2.08
Stapleton	12.0	0.39	1.00	2.63
Livingston	14.0	0.06	0.25	0.88
W. New Brighton..	13.5	0.66	2.00	5.04
Elm Park.....	14.5	0.68	2.00	5.37
All Stations.....	....	1.98	5.75	16.00

* Million gallons per day of 24 hours.

Outlets.—All the outlet pipes through which the effluent from the various treatment works will be discharged will extend into deep water where the currents are swift.

In the Quarantine subdivision, it is proposed to make use of an existing 20-inch cast-iron outlet sewer which extends out to a point about 225 feet from the present shore line. This pipe will be of sufficient capacity to last for many years, and it should be extended to, or nearly to, the pierhead line. When necessary, another outlet pipe can be added.

17 There is at present a 3-foot wood stave pipe running to the outer end of the municipal ferry pier at the foot of Canal street, Stapleton, through which pipe the dry-weather flow from the tributary sewers is carried to deep water. This pipe is of sufficient size to carry the effluent from the proposed Stapleton treatment works for many years, and could be made of use. When the pier is extended to the established pierhead line, the outlet pipe should be extended also. When necessary, another outlet can be built at the foot of Prospect street.

From the Livingston treatment works, it is proposed to lay a submerged 24-inch cast-iron pipe to deep water beyond the pierhead line and, when necessary, another outlet pipe can be laid.

Although greatly increased capacity of outlets from the West New Brighton treatment works will ultimately be needed, a 3-foot pipe will be ample in size for a long time. It would probably be practicable to lay a wood-stave pipe under the existing pier at the foot of Bodine street and to extend the outlet for some distance into deeper water by means of a submerged cast-iron pipe.

From the Elm Park treatment works, it is proposed to lay a submerged 20-inch cast-iron pipe into deep water at a considerable distance beyond the pier-head line. This pipe will be of sufficient size to last for a number of years. It can be supplemented by another pipe when greater capacity becomes necessary.

Treatment Works.

Forms of Treatment Proposed.—The form of treatment proposed for the sewage is coarse screening and sedimentation, and is the same for all the subdivisions except the Quarantine. A period of from two to three hours should be allowed for settlement. It is believed that the deep water and strong currents along the shores of this district will afford ample opportunity for the diffusion and digestion of sewage in such quantities as may be expected from this portion of Staten Island, if it is treated in the manner proposed, and discharged from submerged outlets into water of 30 feet or more in depth and good current.

The successful protection of the water along these shores will, however, depend somewhat upon the measures taken elsewhere for the betterment of the harbor. The present pollution along the northern, and particularly the northeastern, shore of Staten Island is, to some extent, due to the condition of the harbor water in general.

Passage through grit basins, coarse and fine screens is the form of treatment proposed for the Quarantine subdivision, as the opportunity for diffusion and digestion of the sewage by the harbor waters is here especially favorable.

At the treatment works for all the subdivisions, grit chambers, with a settling period of from one to two minutes, will be
18 provided. Where screening is to be used, the grit chamber will prevent heavy deposits which might occur in the outlet pipes or on the harbor bottom near the points of discharge. Where settling tanks are to be used, the grit chambers will guard against trouble that would occur from the deposition of heavy solids in the tanks which are intended for the sedimentation of organic matters.

Sites for Treatment Works.—Many factors have affected the choice of sites for treatment works in the various subdivisions. Among the chief considerations have been the existence of undeveloped land of sufficient area for plants of the size which will ultimately be necessary, the location of these areas at such points as may be best suited to an economical collection of the sewage, this collection being accomplished, as far as possible, without the use of pumping machinery, proximity to any serviceable sewage outlets that might occur, and favorable location with respect to railroad facilities.

At the foot of Nautilus street, there is ample room for locating a screen and for the Quarantine subdivision.

The best site for the location of settling tanks for the Stapleton subdivision seems to be on the west side of Front street between Water and Prospect streets. This location is contiguous to the railroad, and the greater part of the site is occupied by an old asphalt plant and storage yard which is out of use and for sale. On the Water street front there are a few old tenements. By a judicious arrangement of tanks, it will be possible on the area available to treat all the sewage that is likely to reach this point. If, for any reason, the purchase of this land is deemed inadvisable, there are other unoccupied sites in the immediate neighborhood which probably could be obtained.

The proposed site for the Livingston treatment works is west of Kissel avenue between Richmond terrace, as it is to be re-located, and Livingston place. There may be opposition to the establishment of treatment works here, but it is the logical place for them and, if the tanks are properly operated, no offense should be created.

The best site for treatment works in the West New Brighton subdivision is near the garbage incinerator. Economy of operation should result from their location at this point. The block bounded by Starin avenue, Dongan street, Richmond terrace and Bodine street, seems to afford the best site for the works and has therefore been selected. There probably will be plenty of room within this area, even without including the lots bordering on Richmond terrace, to treat any volume of sewage which needs to be collected at this point.

In the Elm Park subdivision, the most favorable site seems to be

at the east corner of Richmond terrace and Newark avenue, although there is a considerable amount of unoccupied land in the
19 vicinity. A location much farther to the west would be inadvisable, if for no other reason than on account of unfavorable conditions which exist there for the discharge of sewage.

Capacities of Treatment Works.—In designing the treatment works, sufficient capacity should be provided to take care of the volume of sewage to be expected for a reasonable period in the future. Nevertheless, the tank capacity to be provided in the first installation should not exceed the economical limit, as units can be added when necessary.

The following table gives the estimated average daily amount of sewage which might have been brought to the various works had they been in existence in 1910, and also the capacities which were used as a basis for estimates of cost of construction and operation and which are deemed reasonable as capacities to be provided for in the first installations.

Sub-division.	Average sewage flow—Mgd.*	
	Estimated for 1910.	Treatment works, first installation.
Quarantine	0.96	3.0
Stapleton	2.26	6.0
Livingston	1.46	4.0
W. New Brighton	2.06	6.0
Elm Park	1.12	3.0
All Sub-divisions	7.86	22.0

* Million gallons per day of 24 hours.

Disposal of Sludge.—The sludge produced in this division may be disposed of in various ways. For many years the amount of sludge will be comparatively small. In 1910, the digested sludge from two-story settling tank installations in the four subdivisions for which they are proposed might have amounted to 18 tons a day. When the capacities of the first tank installations are reached, the amount of sludge will probably be about 38 tons a day.

The treatment works in the district are so placed that the sludge can be transported by water or rail. It would be possible, therefore, to dispose of it either at sea or on land. The presence of two garbage incinerators, both almost directly on railroad lines, would make it feasible to burn the sludge and garbage together. Centrifugal dryers might be placed at each disposal plant to dry the
20 sludge before transportation, or it might be more economical to install such dryers at one or both incinerators and transport the larger volume of wet sludge to the incinerators in proper cars.

There is a large amount of waste land along the railroad line in the northwestern part of the island, near Arthur Kill, which would be suitable for filling with the dried sludge from the settling tanks,

If the sludge were transported hither without previous drying, it would probably be necessary to establish drying beds near the railroad before the sludge could be made available for filling purposes.

If the sludge is to be disposed of at sea, it would be advisable to collect it at one or two points, to avoid construction of piers and loss of time in the operation of sludge steamers. For the purposes of this report, it has been assumed that all the sludge would be delivered wet into tanks located at the Stapleton treatment works, from which tanks a sludge discharge pipe would run out on the municipal pier. By this plan no new piers would have to be built and the sludge steamers passing out of the harbor from other treatment works would have to deviate only slightly from their course to serve as carriers for the Staten Island sludge.

Cost of Main Drainage Works.

The estimated costs of the main drainage works proposed in this report, not being based on detail designs, are necessarily of a preliminary nature.

The following tables give a concise summary of the estimated cost of construction and of the annual charges for maintenance and operation. The costs of land and rights of way are not included.

Estimated Cost of Construction.

Sub-division.	Sewers.	Pumping stations.	Outfall pipes.	Grit chambers.	Treatment works.	Total without Engin'g, etc.	Engineering & contingencies, 15%.	Total Costs.
Quarantine	$38,225*	8,000	6,000	.....	8,000‡	60,225	9,035	69,260
Stapleton	62,430†	10,000	3,000	3,500	63,000	141,930	21,290	163,220
Livingston	84,395	6,000	12,000	2,500	42,000	148,095	22,215	170,310
W. New Brighton	164,305	12,000	17,400	3,500	63,000	260,205	39,030	299,235
Elm Park	62,125	12,000	13,500	2,000	31,500	121,125	18,170	139,295
Whole District	$412,080	48,000	52,500	11,500	207,500	731,580	109,740	841,320

21 Estimated Annual Cost of Maintenance and Operation.

Sub-division.	Annual cost of maintenance and operation.		
	Without fixed charges.	Fixed charges.	Total.
Quarantine	$3,820	3,505	7,325
Stapleton	5,127	8,260	13,387
Livingston	4,694	8,618	13,312
W. New Brighton	7,584	15,142	22,726
Elm Park	5,742	7,048	12,790
Whole District	$26,967	42,573	69,540

* Including Force Mains.
† Including Siphons.
‡ Grit and Screen Chamber.

(Here follows map of proposed sewer-disposal project for Borough of Richmond.)

1 COMPLAINANTS' EXHIBIT No. 202. James D. Maher, Commissioner.

NEW YORK CITY, May 19th, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York's Sewage.

VI.

Study of the Collection and Disposal of the Sewage of the Lower Hudson, Lower East River, and Bay Division.*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.
February, 1913.

2 *Preliminary Report VI.*

Study of the Collection and Disposal of the Sewage of the Lower Hudson, Lower East River, and Bay Division.

Contents.

	Page.
1. Boundaries and topographical Features	3
2. The Existing Sewers, Their Outfalls and Resulting Nuisances	7
3. Possibility that the Sewers of Manhattan Will Have to be Rebuilt	10
4. Quantity and Composition of the Sewage	16
5. Impossibility of Disposing of All the Sewage Through Dilution with the Harbor Water	19
6. Ratios of Sewage to Water	24
7. Possible Methods of Sewage Treatment	31
8. Plan for the Disposal of the Sewage of this Division	35
9. Collecting the Sewage to the Outlet Island	41

Appendices.

I. Studies for Grit Chambers, Screens and Regulators	49
II. Studies for Tide Gates	53
III. Studies for Submerged Outfalls	55
IV. Opinion of U. S. Engineers on the Proposed Island	61

*This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service. Some features of this report will remain open for revision until the final report is submitted.

3 *Study of the Collection and Disposal of the Sewage of the Lower Hudson, Lower East River, and Bay Division.*

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: This report, the sixth in this commission's series of Preliminary Reports on the Disposal of New York's Sewage, is issued with the object of making public, at the earliest practicable date, this commission's studies as to the way in which it will be necessary to deal with the sewage of the fourth, and last of those divisions into which New York has been divided to facilitate the work.

While many details still remain to be considered, these studies show the general character of the works which should be constructed. To protect the Harlem and Lower East Rivers, large sewers are needed to intercept the sewage and carry it to an artificial island to be built near the outer limits of the harbor about three miles from shore; here, after a short and inoffensive treatment the sewage can be discharged into the ocean with confidence that the organic matters will be promptly rendered inert. All the rest of the sewage in this division should be passed through screens and grit chambers and discharged beneath the surface of the water in the main tidal channels.

1.—Boundaries and Topographical Features.

The territory in the Lower Hudson, Lower East River and Bay Division lies on both sides of the Lower East river, the west side of Manhattan and the east side of Upper New York bay. It extends from the extreme northwestern boundary of the city to below the Narrows.

It contains the largest population, and the most densely settled sections of any of the four divisions into which the commission has divided New York for the purpose of planning the main drainage and sewage disposal works which will be required. Within it lies the major part of the Boroughs of Manhattan and Brooklyn, which were separate cities until 1898.

This division is bounded on the east by a line which begins at Bensonhurst on Gravesend bay, runs in an irregular course northeasterly to Forest Park, in the Borough of Queens, and thence northwesterly to the East river near the mouth of the Harlem river. All of that part of Brooklyn and that part of Queens which lie to the west of this boundary line are included in the division.

4 Crossing the East river the boundary enters upon Manhattan Island at East Eighty-second Street, proceeds northwesterly to Central Park West, which it crosses at Ninety-first Street, and thence follows an irregular northerly direction along the height of land to the Harlem river at Spuyten Duyvil. That part of Manhattan, which lies to the south and west of the boundary so described, lies in this division. A small part of the division borders on the Hudson between Spuyten Duyvil and Yonkers. The west-

ern boundary of the division is formed by the Hudson river, Upper New York Bay, the Narrows and a part of Grave-end bay.

In the northern and southern parts of this division the topography is favorable to drainage, but there are large areas near the center which are so low and flat that the construction of sewers with sufficient grades to insure self-cleansing velocities and outfalls so situated as to provide for a free discharge at all stages of tide is impossible.

Made Land.—Many of the sewers in Manhattan feel the effect of the rising and falling tide for a considerable distance from the shores, in some instances, for over one mile. The worst cases of this kind are usually ascribable to the inadequate filling of low-lying or submerged areas as the beds of creeks and the once marshy shores of water courses. A remarkable regular shore line, made by filling in Manhattan, is shown on modern maps.

TABLE I.

Acres of Filled Land in this Division.

Borough.	Acres.
Manhattan	1,140
Brooklyn	1,520
Queens	460
Total	3,120

The filling has been largely, but not entirely, done along the water front. From 82nd Street on the Hudson river, southward, to the Battery, and thence northward along the Lower East river to 33rd Street, Manhattan, the marginal street is entirely on made land, the total length of shore so recovered being ten and one-half miles.

In many instances the made land extends some blocks back
5 from the river front and in the neighborhood of Canal Street, Manhattan, it runs across the island, a distance of nearly two miles.

On the Brooklyn shore, the made land extends from a point north of Newtown creek to near 45th Street, South Brooklyn, a distance of eight miles. The Brooklyn Navy Yard is entirely on made land. A large area in the neighborhood of Red Hook and Gowanus canal, Brooklyn, has been reclaimed by filling.

The growth of made land has been gradual. It has increased with the increasing size of the city. The chief object in filling in the low-lying places has been to eliminate swamps and marshes and make the area of ground available for trade and commerce more extensive than originally existed. At the same time the filling has proved a convenient means of disposing of refuse.

If cellar earth and other suitable refuse material were utilized in filling in the swamps and meadow lands which exist in the outlying parts of New York City, the shore lines in parts of the harbor estu-

aries which are now seriously polluted would soon be straightened and the water would be more easily kept clean than under the existing circumstances.

To facilitate the filling in of the low-lying shores, the Harbor Line Board, composed of engineer officers of the U. S. Army, which has charge of maintaining the navigable channels of the harbor, has established lines for solid filling. These lines extend throughout the harbor and give a good idea of the plans to which future operations of filling will probably conform.

The land which lies in this division at elevations within twenty feet of mean sea level, includes all the filled land and also some additional areas mostly in Brooklyn and Long Island City. A broad belt runs from the head of Newtown creek to the vicinity of the Brooklyn Navy Yard. The total area below twenty feet elevation in this division is about 3.3 square miles in Manhattan; 6.5 square miles in Brooklyn and 2.9 square miles in Long Island City. Seventy-three per cent. of all the land in this division is of more than twenty feet elevation above mean tide. In Manhattan the high land lies for the most part near the center of the island. The highest point is somewhat above 100 feet, and is situated north of 77th Street. There is no point above sixty feet elevation further south than 33rd Street.

In Brooklyn the land, which lies at an elevation above sixty feet, exists chiefly in the eastern part of the division, where a well recognized ridge runs in a northeasterly direction from the vicinity of the Narrows. Elevations of 100 feet or more frequently occur on this ridge.

6 Tidal Range.—The difference between mean sea level and mean high water is one-half the mean tidal range as given in the Table II.

TABLE II.

Range of Tide in New York Harbor.

	Mean.	Spring.
Lower bay, Sandy Hook	4.7	5.6
Narrows, Fort Hamilton	4.6	5.6
Upper bay, Governor's Island	4.4	5.3
Hudson river, Spuyten Duyvil	4.0	4.8
East river, Hallett's Point (Hell Gate)	5.5	6.6
East river, Throg's Neck	7.2	8.5
Harlem river, High Bridge	6.0	7.2
Kill van Kull, Shooter's Island	4.6	5.5
Newark bay, Passaic Light	4.7	5.7
Passaic river, Newark	5.0	6.0

Geology.—The superficial geological formation of this division is recent except for a small low-lying area of stratified drift in and near 125th Street. The surface of Manhattan island as far south as

23rd Street is composed chiefly of mica schist rock. South of 23rd Street, the rock disappears and stratified drift predominates.

In the Brooklyn part of this division, drift exists on each side of the central ridge, the ridge itself exhibiting the features of a terminal moraine with till on the western slope. Swamp and marsh lands exist to a limited extent, and then only in that part of Queens which lies in this division.

Value of Land.—The most valuable land in this division lies in the central and southern parts of Manhattan. It is a peculiar fact that whether for business or residence purpose, the most costly land lies along the center of the island. At the southern extremity is the financial district. North of this is the City Hall with the central post-office, numerous newspaper offices, the principal law courts and municipal administrative headquarters. Next above follows the wholesale dry goods center, then the region of retail shops, hotels and theatres and finally areas of high-class private residences and apartment houses which extend to the northern limits of this division. From this central zone east and west to the river front lie areas occupied by factories and residences, the latter ranging from modest dwellings to congested tenements.

In Brooklyn the water front is chiefly occupied by large factories and warehouses. The most crowded residence district and the center of financial administrative activity lies in that part of the borough which is opposite the southern end of Manhattan Island.

7 2.—The Existing Sewers—Their Outfalls and Resulting Nuisances.

Practically the whole of this division is sewered on the combined principle of sewerage.

In addition to the sewage which comes from the storm water of the streets and from the interior of the houses, the sewers of Manhattan and Brooklyn are required to carry away the water which falls upon the roofs, yards and courts of the buildings. The connections are trapped in order that the air from the sewers shall not enter the houses. The plumbing of the houses is ventilated by extending the soil pipes to the roofs.

In many cases, especially in Manhattan where the cellars of large buildings are deep, it is often necessary to pump the sewage into the street sewers. This is done at private expense.

Relief Sewers.—In most of Manhattan the sewers, which are large and short, have generally proved adequate to the requirements of the growing population; but in Brooklyn much trouble has been experienced from the insufficient provisions which were early made for drainage. The first sewers were built when the populations which they were required to serve were small and scattered, and when a comprehensive system of sewers was built betwen 1850 and 1860, the rainfall data were inadequate to permit designers fully to understand the requirements. With the increasing population the original sewers have been supplemented by large and expensive relief sewers, and these in turn have had to be assisted in some cases by the con-

struction of intercepting sewers for the collection and removal of storm water.

The sewers of Manhattan and Brooklyn are of many shapes and sizes. Among the older sewers of Brooklyn are many storm drains whose courses are not known. The older sewers are generally circular in shape, and when over twenty-four inches in diameter are of brick or concrete. Clay and cement pipe have been extensively used for the smaller sizes. Since 1907 the principles of design and construction have been much improved in Brooklyn.

Most of the sewer outlets on the Manhattan shores are between two and five feet in diameter, but there are some which have a section equivalent to a circle having a diameter of ten feet and more. The outlets on the Brooklyn shore are somewhat less numerous and some are larger than the largest of Manhattan, having a section equal to a circle with a diameter of fifteen feet.

Many of the sewers of Manhattan were built many years ago. They represent various periods of growth due to the introduction of public water supplies and other causes and have been extensively reconstructed and repaired within recent years.

8

Throughout this division the sewers are provided with catch basins at the street corners which were intended to convey the storm water from the gutters and protect the sewers from grit and other solid substances.

Ventilation.—It was intended that the sewers throughout this division should be ventilated through perforations in the manhole covers located at frequent intervals in the street. In most parts, notably in the older sections near the water front, the ventilation is defective, partly as a result of the settlement of the sewers, the entrance of tide water and the submergence of the outlets. Nuisances frequently result where steam and hot water are discharged into the sewers, since hot vapors rise and issue through the manhole covers disseminating odors of cooked sewage.

Outlets.—The outfalls of the sewers of this division, as elsewhere in the metropolitan district, are located at the bulkhead or shore line or, frequently in Manhattan, near the outer ends of the docks and piers.

The submergence of the sewer outfalls, as at present, and the rising of the tide drive the foul air into the streets and produce coatings of grease and solids upon the sides of the sewers, and this interferes with the flow of sewage. So much deposit is produced in some of the sewers that a cleaning gang, working continuously, can make no appreciable reduction in the depth of the deposit. Congealed grease has been found to measure as much as a foot in thickness in some of the sewers of Manhattan.

Physical Condition.—Inspections of the sewers made by the Metropolitan Sewerage Commission with the co-operation of the Bureau of Sewers and the Borough President of Manhattan have revealed many examples of distorted shapes, worn out inverts, sunken arches, and cracks due to settlement. In many places irregular holes had been broken through sewers in making connections, and the holes never properly repaired. It was impossible to enter some of the

sewers for inspection owing to steam and hot water escaping from neighboring buildings. Other sewers could not be entered on account of the presence of illuminating gas in such quantities as to endanger health. In other areas, lanterns could not be carried into the sewers on account of gasoline vapor, presumably from automobile garages or other establishments using this explosive compound.

In Manhattan the sewers are inspected and cleaned only on complaint. The sewers are not flushed, but are cleaned by hand. Street sweepings are frequently pushed into the catch basins against orders in Manhattan and Brooklyn.

9 Catch Basins.—The effect of the catch basins is comparatively slight. They soon become filled with grit and other solid matters. To be of material use, they should be cleaned after nearly every storm. This is not done. The records for the year 1909 show an average of one cleaning for each catch basin in Manhattan every 5.3 months. This does not mean that all the 6,348 catch basins in the borough were cleaned. Some were cleaned out at compartively frequent intervals and others were not cleaned at all.

In the year 1907 the catch basins in Brooklyn were cleaned on an average about 2½ times a year and the quantity of deposits removed aggregated 35,272 cu. yds. The cost of removing this material was $1.12 per cubic yard. The incompleteness and great cost of removing solid matter from sewage by the use of catch basins can be readily understood from these figures.

Large quantities of solid matters which pass the catch basins are deposited in the sewers themselves and are eventually removed by hand, washed out by the flood water of storms, or carried away through the alternate choking and flushing action which is produced by the rising and falling tide.

About 400,000 cubic yards of deposits are dredged each year from the slips and docks of that part of Manhattan which lies in this division by the Department of Docks and Ferries and large quantities are also dredged by private enterprise and from the Brooklyn shores. It is generally conceded that this solid material comes chiefly from the sewage. The water from which the deposits are taken is often black and offensive and gases of putrefaction rise in innumerable bubbles from the deposits at the bottom. During flood currents the sewage matters are driven back into the slips and in this quiet water some of the solid matters are deposited. On the outgoing tide grease and excreta are left adhering to the dock walls and piers. In the immediate vicinity of the outfalls the water is discolored and objectionable in appearance and odor. In some cases many acres are rendered turbid by the sewage.

Local Nuisances.—Extensive nuisances occur in this division at various points along the Brooklyn shores. Gowanus canal, Wallabout bay and Newtown creek are the most conspicuous. These bodies of water are actually large, although small in comparison with the great areas of the main divisions of the harbor. The condition of Gowanus canal, into which a 15-foot relief sewer as well as some eight other sewers ranging from 1½ to 6½ feet in diameter discharge, has been notorious for years. The water is black and

foul-smelling at all times and the sides of the piers, bulkheads and masonary structures are coated with deposits. As a means of improving this canal, the Borough of Brooklyn has constructed
10 a flushing tunnel which leads from the head of the canal to an outlet in the Upper bay. Pumps force the water from the head of the canal through the tunnel, which is 6,270 feet long and 12 feet in diameter. The outlet is about 2 feet below low tide and is situated close to the shore between two long piers. The water in the vicinity of the outlet is strongly discolored when the pumps are in operation, the discharge from the tunnel being visible at times for a distance of more than a mile.

Wallabout bay in the Lower East river is polluted by a 9-foot sewer which discharges at the bulkhead line. The point of discharge is so protected from the tidal currents that a satisfactory dispersion of the sewage cannot take place. The bay is exceedingly offensive at all stages of tide, the bottom being covered with putrefying sewage sludge and the top with sewage apparently in an undiluted state. These objectionable conditions are in front of the New York Navy Yard.

Newtown creek, which empties into the Lower East river from a low-lying manufacturing district north of Brooklyn, is an offensive body of water. It supports a heavy traffic. Considerable quantities of manufacturing wastes are discharged into the creek from warehouses, elevators and factories, which line both banks. Some sewage empties into it, although the further pollution of this stream is prohibited by law. A 15-foot sewer, constructed through the joint action of the Boroughs of Brooklyn and Queens, empties into the head of Newtown creek and although this sewer was intended to accommodate storm water only, the dry weather flow being diverted, considerable pollution is ascribable to it.

There are no figures available to show the total cost of the sewers which exist in this division. It has been estimated that those of Manhattan exceeded $26,000,000, and it is believed that those of Brooklyn have cost about an equal sum. There are about 522 miles of sewers in Manhattan and about 814 miles of sewers in Brooklyn.

3.—Possibility That the Sewers of Manhattan Will Have To Be Rebuilt.

It has seemed to those charged with the duty of maintaining the sewers of Manhattan, as well as to consulting engineers who have been called upon to examine into the subject, that it would eventually be necessary to reconstruct a large part of the existing sewers of Manhattan.

The chief reason for reconstruction lies in the need of repairs and the harm done to the sewers from the building of underground structures of various kinds, as, for example, passenger subways, conduits for electric light, telephone and telegraph and pipes
11 for water, gas, steam and pneumatic mail service. As the city is entering upon extensive subway construction, it may be well to consider whether the interferences which now exist or are to be expected will not cause so much expense and make the

sanitary removal of the sewage so difficult that a reconstruction of the sewers will be a practical necessity. If the sewers are to be rebuilt, this fact should be known and preparations for it made at once so that such saving as can be effected in the cost of temporary alternations can be accomplished.

Right of Way of Sewers.—Of all the many structures beneath the city's streets, it is most important that the sewers should have the right of way. Unlike pipes for water, gas or electricity, which operate under pressure, sewers, whose flow is due alone to gravity must be laid to proper grade and alignment or they will not operate properly.

To be self-cleansing, sewers should maintain a certain velocity of flow and any reduction in the grade which checks the velocity will lead to deposits. Short turns and bends and changes in the cross section also alter the flow and interfere with the proper function of the sewer.

When it is remembered that sewerage systems should be well designed and constructed; that they are built under the ground in a manner which is intended to be permanent and durable; that they cannot be altered in size, shape, grade or location without harmful consequences; that their function is to carry off promptly and completely the most offensive and dangerous wastes of a city, the claim of the sewerage system for right of way beneath the streets appears to be fully justified. That this claim has not been respected is a regrettable fact. In defiance of the officials charged with the duty of maintaining the sewers, they have been moved from place to place, pierced and damaged in many ways. Instead of being used for the purposes for which they were built, the sewers have been abused by the discharge into them of harmful manufacturing wastes, hot water and steam and been rendered dangerous for inspection by the illegal emptying of gasoline and other inflammable compounds.

The structures which interfere with the sewers are located at depths which range from that of the shallow conduits which carry the current for the surface railways to that of the passenger subways. The passenger subways form a serious obstruction. They are situated as close to the surface of the street as practicable in order to facilitate entrance and exit and they require over 20 feet of depth. For the most part the subways, like the water, gas and other large mains run longtitudinally through the island and the sewers in seeking their outlets to the rivers run perpendicularly to them.

12 Interference from Subways.—The first subway for passengers was built on a line which divided the sewerage systems of Manhattan into approximately two equal groups, the subway following along the axis of the island for most of its length. The interference with the sewers was, in this case, as slight as possible, it being feasible to cause the sewage to flow in many instances with but little alteration of the sewers to a convenient point of discharge to one of the nearby rivers on the east or west side of the island. But other subways which had been designed will run in lines nearly parallel to the first and will divide the sewers further. There will be no easy readjustment possible, as in the first case, for there will

be a central area which will be blocked off by the subways from the river on either side. In order to carry the sewage past these new subways, it will be necessary to make extensive reconstructions. It will be necessary to collect the sewage to more or less suitable points in the areas between the subway lines and then conduct it by siphons beneath the subway structure to points from which it can flow away by gravity. The alignment and grade of the sewers will, in many cases, be seriously interfered with. The siphons which should be capable of being emptied, inspected, repaired and cleaned, will be costly to build and, when of considerable depth, difficult to maintain. Sewage which now flows directly across the island will have to be diverted so as to run for considerable distances longitudinally, with the result that there will be a tendency to loss of velocity and formation of deposits in the drains.

Need of Repairs.—An important argument for reconstructing the sewers of Manhattan lies in the need for repairs. Inspections made by the Metropolitan Sewerage Commission have shown that some of the sewers, and especially the older ones, are in dangerous condition. Of 246 inspections, 38, or one-sixth, showed places where the sewers will have to be rebuilt within a few years on account of defective brick work alone. These locations exist along the whole length of the island. Of the 522 miles of existing sewers in Manhattan, 55 miles are seriously out of repair. To repair these, would involve an outlay which could more profitably be spent on new construction.

Separate vs. Combined System.—If the sewers were reconstructed, it is the opinion of many engineers that they should be built upon the separate system. Drains for storm water should be laid close to the surface of the streets and should be large and have ample grades to carry off much solid matter. When street washing, which is rapidly coming into favor, becomes general in the city, the quantity of grit and other solids to be removed by the sewers will increase. To a great extent the storm sewers should be made to carry off snow. Storm sewers should be built without catch basins at the street corners and should lead to central points where grit and
13 other heavy materials can be removed before the sewage is discharged into the harbor. The elimination of the 14,000 catch basins which now exist would be desirable.

Sewers for house drainage should be laid so far beneath the surface of the streets as to permit the sewage to flow into them by gravity. They should be sufficiently deep to pass clear of all other subterranean structures. The comparatively small size which the sewers for house sewage would require would permit them to be located, even in congested streets, so as to give good alignment and grade. The sewage would thus be more promptly carried away than under present circumstances. In general these sewers would run perpendicular to the subways, crossing under them and delivering at suitable places into interceptors for conveyance to sewage disposal works or pumping stations.

Objections Against Reconstruction.—The objections to the reconstruction of the sewers of Manhattan lie in the expense and incon-

venience which the reconstruction would directly and indirectly entail upon the public. Almost all the streets of the city would require to be opened and the large quantities of earth and materials of construction would have to be handled without stopping vehicular traffic where the alterations were going on. The plumbing of over 150,000 houses would require to be altered so that the proper sewer connections could be made.

It is not clear how the storm water sewers, which should be laid close beneath the surface of the streets could escape the underground trolley conduits above, and the passenger subways beneath, in the longitudinal highways. There should be no siphons on these storm water drains.

Storm Water.—If the house sewage and storm water were collected separately, the disposal of the sewage would be facilitated, provided the storm water was not treated also.

It is not customary for cities to build works to treat all their storm water. The volume is so great, even when moderate falls of rain occur, that the works required to purify all the storm water would be excessively large and costly. There is, moreover, a general belief that the waste water from the roofs of houses and from the streets does not contain enough putrescible material to add materially to the pollution.

The literature relating to the treatment of storm water shows that experts generally consider that storm water from closely built-up cities is capable of producing at least as much offense as house sewage. There is reason for believing that the first flush of storm water is worse than even the relatively concentrated sewage of European cities, and that it is therefore desirable to treat a portion of the storm water.

14 European and American Sewage.—Much of the recorded information and opinion which exist with respect to the polluting effects of storm water is based upon European conditions, where the quantity of sewage at times of dry weather may amount to 20 or 30 gallons per capita per 24 hours. If the quantity of sewage in American cities is taken at 120 to 180 gallons per capita, it is evident that the argument for treating storm water has more weight in America than it has abroad, for if storm water is as bad as domestic sewage when the latter is concentrated to the extent of 20 or 30 gallons per capita per day, it must be about six times as bad when the domestic sewage is so dilute.

The aggregate weight of solid matter carried by storm water is very great. Analyses can be quoted which show that the percentage of suspended matter is several times as high in sewage containing storm water as it is in purely house sewage. This being so, and it being remembered that the volume of sewage is greatly increased at times of storm, it follows that the total amount of suspended matter carried by a given volume of storm water is much greater than the analyses indicate.

Numerous experts have expressed the opinion that careful attention should be given to the polluted character of the first flush of storm sewage. In the opinion of Samuel Rideal, whose familiarity

with the chemical and biological composition of sewage and whose knowledge of current practice in England entitles him to be regarded as an authority, "whatever system be adopted, the raw storm water of populous districts should never be allowed to pass in large volumes at the beginning of a storm directly into a stream." Dr. Dunlap, Director of the Hygienic Institute at Hamburg, and an authority on sewage disposal on the Continent of Europe, as well as in England, says: "It must not be supposed that the contents of rain water sewers are in general not so polluted as ordinary sewage. In busy districts, the washings from the streets, even if these are thoroughly cleaned daily, are everywhere found to be worse in every respect, including putrescibility, than ordinary sewage. Dr. Houston, the celebrated English bacteriologist, says that storm water is as "potentially dangerous to health as normal crude sewage." To these opinions many more could be added to the same effect.

American Analyses.—There is scant information on record to show the composition of storm water in American cities, although some data are available to indicate the average composition of sewage containing the combined drainage of houses and streets. This information is not as valuable as it would be if it had been collected with the intention of showing the difference in composition which occurs in the sewage of a given city during dry weather and at periods of storm, but some facts exist with respect to this subject.

15 At a testing station, established at Gloversville, N. Y., at which analyses were made continuously for about one year, 1908-1909, the marked effect of storm water upon the dry-weather flow was shown in the following manner. Following a period of dry weather, rain fell for practically 24 hours on June 5 and the flow of sewage increased 31 per cent., although comparatively few storm-water drains were connected with the sewers. The storm water came chiefly from the roofs of houses and from the streets. The strength of the sewage increased as follows:*

Total suspended solids from 312 to 622 parts per million, or 166 per cent.

Volatile suspended matter from 196 to 254 parts per million, or 73 per cent.

Fixed suspended solids from 116 to 368 parts per million, or 324 per cent.

It is worth noting that the largest increase in suspended matter was due to non-volatile, fixed or mineral matter. This suggests that storm water is peculiarly susceptible of improvement by settlement, an inference which is not strictly correct, for the removal of mineral matter would not produce nearly as much benefit as the removal of organic or nitrogenous matter. A large part of the suspended matter is grit.

The average composition of the combined sewage of some American cities, as determined by numerous analyses made at investigating laboratories, is indicated in Table III.

* Report to the City of Gloversville, N. Y., by Eddy and Vrooman, Aug. 7, 1909, p. 57.

Table III.

Composition of Sewage at Various Testing Stations.

(Parts per Million.)

	Suspended solids.				Nitrogen as			Oxygen consumed.			Cl.	Fat.
	Total.	Fixed.	Volatile.	Organic.	Free Am.	Nitrite.	Nitrate.	Total.	Sus.	Dis.		
1. Boston, 1903-5	...	...	...	....	18.5	.19	.10	43.1	19.3	23.8	...	...
2. Boston, 1905-7	135	44	91	9.1	13.9	.09	.29	56.9	13.0	43.0	..	...
3. Columbus, 1904-5	209	130	79	9.0	11.0	.09	.20	51.0	25.0	26.0	65	25
4. Waterbury, 1905-6	165	50	115	14.8	7.8	.14	1.52	46.0	20.0	26.0	48	26
5. Gloversville, 1908-9	406	177	229	23.0	12.0	.38	.87	95.0	50.0	45.0	158	48
6. Philadelphia, 1909-10	189	59	130	6.3	4.0	.23	1.00	76.0	...	40.4	39	28

16 In each of the investigations whose results are indicated in the foregoing table, an effort was made to obtain results which would be helpful in the design of works for the purification of the sewage. Certain peculiarities were thought to exist in the sewage to be dealt with which it was necessary to determine and the amenability of the sewage to purification was tested in each case.

It will be observed that the sewages tested at the experiment stations varied considerably in the amount and nature of the suspended matter, as well as in the dissolved impurities. If partial treatment only had been thought sufficient, it would not have been necessary to make the analyses so complete. So far as the general character of the average sewage dealt with is concerned, the figures given are satisfactory, but they should be employed with caution in forming an opinion as to the composition of the sewage of other cities where importance attaches to questions of detail.

Opinion With Respect to Manhattan and Brooklyn.—Should the house and storm sewage of Manhattan be collected in separate systems, it would be desirable certainly to treat all of the one and perhaps part of the other. This could not conveniently be done in the same plants. Should both house and storm sewage be collected by the combined system, the treatment works should be so designed as to deal with the dry-weather flow and have enough more capacity to take care of the heavily polluted water which would be washed from the streets and houses with the first flush of the rain. It would be well to have the capacity of the main sewers and disposal works equal to twice the average dry-weather flow.

4.—Quantity and Composition of the Sewage.

The quantity of the sewage produced in this division can be estimated from a knowledge of the water consumed and the rainfall. But few of the sewers have been gauged and exact measurements of their flow are not available. As compared with many cities, especially those of Europe, the volume of sewage is large and its composition variable. It is, for the most part, remarkably fresh when discharged, owing to the short distance, and consequently brief time, consumed in passing from the houses to the outfalls.

The conditions of residence and manufacture are various in this division and the sewage which reaches the outfalls is correspondingly variable. The quantity produced is different at different hours of the day and night; and it is not the same at all seasons of year. Owing to the fact that most of the sewers for some distance from the shores of the harbor are choked with tidal water, the sewage is often mixed with salt water before it is discharged. In some cases
17 the sewage is warm with the waste water and hot water which is discharged from large office buildings, hotels and manufacturing establishments.

At times of rain much polluting water is washed from the streets. The quantity of this material is doubtless increasing, due to the more extended practice of washing the streets with water. After snow storms, snow is, to some extent, discharged into the sewers and with

it more or less solid matter, which was either present on the pavements before the beginning of the storm or is thrown out after the snow begins to fall.

In the report of the Metropolitan Sewerage Commission, dated August, 1912, pp. 28-30, is given an estimate of the composition of the sewage and the quantities produced in various parts of the metropolitan district. The composition is based on an ideal sewage whose constituents are stated. It is shown that about 625 tons of fecal matter is discharged into the harbor every day. Assuming the population in the year 1910 to have been 6,423,635 for metropolitan New York and New Jersey, and supposing that 90 per cent. of this number were connected with the sewers, the total number of persons contributing to the pollution of the waters would have been 5,780,000. The aggregate quantity of polluting matter estimated as dry solid material which was discharged in the year 1910 would have been 266,000 tons. About one-half of this was capable of putrefaction or already advanced to some extent toward that condition when discharged.

Assuming one ton of dry suspended matter to be equivalent to about 45 tons or about 53 cubic yards of wet sludge, it appears that the population of the metropolitan district empties into the harbor each year the equivalent of 12,000,000 tons of sludge, having a bulk of about 14,000,000 cubic yards.

Data relative to the population and sewage flow in different parts of the metropolitan sewage district, including the waters of this division, are given in Tables IV and V.

The Tables.—The eight divisions into which New York harbor has been separated for purposes of study have been described in the commission's report of August, 1912. To these is here added a ninth to include the sewage which is naturally tributary to the Passaic and Hackensack rivers.

In preparing Table I, the dry weather flow of sewage discharged into each division has been assumed to be the same as the volume of the public water supplies of the areas tributary to the respective divisions. Where future quantities are considered, the sewage to be expected is in most cases based on the estimate of the authorities who are charged with the duty of providing the public water supplies.

The populations for 1910 have been taken from the United States census reports; those for 1940 are based on carefully made estimates by this commission, revised with the latest information obtainable.

Table IV.

Populations and Volumes of Sewage Directly Tributary to the Several Divisions of the Harbor.

Division of the Harbor	Sewage.	Year 1905. Sewage Mgd.[1]	Population	Gallons per capita per day.	Year 1940. Sewage Mgd.[1]	Population.	Gallons per capita per day.
Harlem River	Manhattan	70	522,000		156	900,000	
	Bronx	29	275,000		97	748,000	
		99	797,000	124	253	1,708,000	148
Hudson river	Manhattan	98	720,000		238	1,470,000	
	New Jersey	34	283,000		64	470,000	
		132	1,003,000	131	302	1,940,000	156
Upper East river	Bronx	17	156,000		63	452,000	
	Queens	4	26,000		36	197,000	
		21	182,000	115	99	649,000	152
Lower East river	Manhattan	144	1,083,000		189	1,170,000	
	Queens	8	60,000		52	383,000	
	Brooklyn	94	915,000		213	1,670,000	
		264	2,058,000	129	454	3,223,000	141
Upper bay		64	519,000	123	118	908,000	130
Newark bay	Bayonne	1.3	18,000		7.1	51,000	
	Jersey City	0.8	6,000		1.1	8,000	
	Newark	10	67,000		18	115,000	
	Elizabeth	1	12,000		2.6	20,000	
		13	103,000	126	30	200,000	150
Kill van Kull	Bayonne	1.8	23,000		9	64,000	
	Richmond	5	27,000		14	75,000	
		7	50,000	140	23	139,000	165

Jamaica bay			Brooklyn			370,000			670,000	
			Queens			81,000			290,000	
				70	351,000	151	163	960,000		180
Passaic and rivers	Hackensack	New Jersey		130	950,000	137	249	1,500,000		184
Totals				765	6,019,000	...	1,719	11,570,000		...

• Million gallons per 24 hours.

From Table IV it will be seen that the total quantity of house sewage tributary to the harbor in the year 1910 was 765,000,000 gallons per 24 hours, and the population supplying this sewage was 6,019,000. By 1940 the population will be almost doubled and the quantity of sewage will be more than doubled. The sewage expected in 1940 in one day will be enough to fill a reservoir one square mile in area and 10 feet deep.

19

A glance at Table IV shows that a proportionate burden of pollution is not placed upon each division. The Lower East river receives much more sewage than any other division in comparison with its size. This will be true, also, in 1940, if nothing is done to prevent it. At that time over one-fourth of the total amount of sewage produced in the metropolitan district will be directly tributary to this stream. The increase which will go to this division from Brooklyn and Queens will be about half the quantity which was produced by Manhattan in 1910.

Table V has been made from data contained in the report of this Commission dated August, 1912. Of particular interest are the suspended organic and volatile maters.

TABLE V.

Assumed Composition of the Sewage which is Tributary to the Harbor on the Basis of 100 Gallons per Capita per 24 Hours. The Quantities are Expressed in Parts by Weight per Million of Water.

Solid Matters	800	Nitrogenous	150
Dissolved	500	Nitrogen	15
Suspended	300	Non-Nitrogenous	250
Organic and Violatile Matters	400	Fats, etc.	50
Dissolved	200	Total Carbon	200
Suspended	200		

5.—Impossibility of Disposing of All the Sewage Through Dilution With the Harbor Water.

The discharge of sewage into a natural body of water is properly termed disposal through dilution. Dilution aids in the disappearance of the sewage, but it is only one of a number of factors which must come into play before the solid and liquid ingredients can permanently disappear.

Oxidation Essential.—For the disposal of sewage to be permanent, it is necessary that the decomposable ingredients shall be transformed into other and simpler chemical compounds. These transformations involve physical, chemical and bacteriological reactions. The final and indispensable change is really one of combustion; oxygen is absorbed and the substances which were offensive, or likely to become so; are mineralized. In this state and by this process alone do they become inert and incapable of producing offense.

It is the aim of all processes of sewage purification to oxi-
20 dize the decomposable ingredients or prepare them for oxida-
tion. In the land treatment of sewage, the ingredients are oxidized near the surface of the ground. In sprinkling filters and contact beds, oxidation is accomplished by bringing the sewage into intimate contact with the air on the surface of broken stones. The effect of dilution is to bring the liquid and solid particles of the sewage into contact with the oxygen which is dissolved in the water In all these processes the end is essentially the same. Oxidation is the object aimed at.

In treating sewage by disposal upon land, in filter beds or in water, the sewage should be freed from its gross suspended solids before it is subjected to the final oxidizing process and if this is properly done, there is likely to be little trouble so long as the quantity of oxygen is sufficient and time enough is afforded for the oxidizing process to become complete.

If the ratio of sewage to oxygen is too great, serious consequences follow and this is as true when sewage is discharged into water as when it is passed through filters or placed upon land. The evil effects include discoloration, the evolution of foul smelling gases and the production of slimy, semi-solid deposits. Land and filters in this condition are said to be sewage-sick and water is popularly called stagnant. The condition is one of putrefaction.

Putrefaction is decomposition in the absence of oxygen. It postpones, but cannot replace, oxidation. Oxidation must eventually take place and if it does not occur promptly and under conditions which are within control, it will occur under such conditions as may accidentally and ultimately offer.

The Supply of Oxygen.—The exact amount of oxygen which should be supplied to sewage in order that decomposition should proceed at the most rapid rate or, at least, at a reasonably rapid rate is probably not determinable. The action is essentially a biological and chemical process in which time and temperature are important factors. The organisms which carry it on must be provided with all the oxygen which they need. It is impossible for them to have too much.

Clean water generally holds a large amount of oxygen. One thousand volumes made up of half sea water and half land water, uncontaminated with sewage and without decomposing matters of any kind, should have at 65 degrees Fahrenheit, 6 volumes of oxygen per litre or about 8.6 parts per million by weight. The harbor water in this division usually contains from two-thirds to one-half of what it should possess. The oxygen that has disappeared is the measure of the organic pollution.

Dilution Required.—As a result of observation and experiment in various parts of the world, engineers have formed opinions as to the amount of sewage which can safely be discharged into a natural
body of water, such as an inland river or lake. The word
2? safely here refers solely to the chance of producing a nuisance, chiefly odor. It has no relation to the effect which the sewage may have upon health.

According to the opinion of American engineers, the dilution must be in the proportion of at least 20 or 25 parts of water to one part of ordinary sewage and there may be conditions where a nuisance may result where the dilution amounts to nearly 50 parts of water to one part of sewage. When the proportion of sewage to water is greater than this, the capacity of the water is likely to be overtaxed. These supposedly safe ratios of dilution are based upon the assumption that the water with which the sewage is mixed is clean and possesses its normal amount of oxygen. Where the water is polluted to begin with the necessary dilution must be much greater.

In the Eighth Report of the Royal Commission on Sewage Disposal of Great Britain, issued at the end of 1912, it is recommended that where the dilution of sewage to water is between 150 and 200 times, the sewage should be purified so that the effluent will not contain more than 60 parts of suspended matter per million and that only when the dilution exceeds 500 times the volume of sewage should crude sewage be permitted to be discharged into a water course. These figures refer to English sewage, which is about 6 times as concentrated as American sewage, and to the water of inland rivers and lakes, but the Royal Commission holds the opinion that the proportions hold generally true for tidal waters also.

A glance at Tables VIII, IX and X of this report will show that the sewage in this division was not diluted with a proper amount of water in 1910, and will be still less adequately diluted in 1940 if measures are not taken to reduce the pollution.

It is worthy of note that the observations upon which American and English experts base their opinions have been made where sewage has been discharged into inland bodies of water. There has been no study of the discharge of sewage into tidal estuaries which would permit of safe ratios to be stated with positiveness for salt water. Such investigations as have been made indicate that sewage solids settle more rapidly in salt water than in land water, and it is believed that gallon for gallon, land water will dispose, in a normal manner, of more sewage than sea water.

It is not always clear how the dilution of sewage can be calculated in sea water. The same, or nearly the same, water often flows backward and forward for days near a sewer outfall, while the discharge of sewage is continuous. Under these circumstances the sewage flow is irregular and its calculation is involved in uncertainty.

22 Errors which may be made in such calculations include the assumption that:

(*a*) The assumption that the flow of sewage is uniform during the 24 hours. It may vary as much as 50 per cent. at different hours.

(*b*) The flow of tidal water is uniform. It is quite the reverse. Aside from the fact that the currents at each turn must gradually slow down to the stopping point and then gradually increase to the normal strength of flow, winds, heavy rain, snow and intense cold may each produce a decided effect upon the volume of water moving in a harbor.

(*c*) The sewage matters become immediately and thoroughly mixed with the waters. The opposite is the fact. Dispersion and

diffusion are difficult to accomplish and consequently there are many kinds and degrees of stagnation.

(*d*) The sewage remains sewage after it is well mingled with the water. This is not true. Chemical changes at once set in.

(*e*) The waters into which the sewage is discharged are free from pollution to begin with. This assumption, however warranted in dealing with an inland river, is quite contrary to the fact as related to New York harbor.

The changes which sewage undergoes when it is discharged into a natural body of water should be carefully kept in mind, and the mistake, often made, of assuming that the sewage remains and can be reckoned with as sewage after admixture should be avoided. In no other way is it possible to obtain an accurate understanding of the subject. It is wrong to speak of sewage matters as sewage two or three hours after they have been discharged into a tidal estuary. Some of the original ingredients may still exist, but the chances are all against the continuance of any of them in an unaltered condition except the grosser solids and such others as may be able to persist in greatly diluted form.

Oxygen Required. It is impossible to say with any useful degree of accuracy how many pounds of oxygen one million gallons of sewage will require in order that the putrefiable ingredients may be rendered inert. The two ways of approaching this subject, that is, by analysis and incubation tests, are, unfortunately, too artificial to show what can reasonably be expected in nature. Predictions as to the amount of oxygen which would be present if a given quantity of sewage was to be discharged into a given quantity of water must, in the present state of knowledge, be considered unreliable.

But if it is impossible to calculate the oxygen requirements of sewage or express in percentages the proportions of sewage to water which may be present throughout a harbor, it is feasible to state, in at least approximate terms, the relation which exists between the volume of sewage and the volume of water present under various circumstances and such calculations may be of some value. They are likely to prove of greatest service when they are expressed in a simple way and are used with other data as a means of obtaining a general opinion of the case.

23

It was in this way, and with all the restrictions and qualifications which a knowledge of the situation imposed, that Prof. Adeney, in a report to the Metropolitan Sewerage Commission, calculated the dilution of sewage in New York harbor (See p. 95, Report Metropolitan Sewerage Commission, August, 1912).

Calculations of Dilution.—Taking his data from the published reports of the commission, Prof. Adeney calculated that about 59,400,000 cu. ft. of sewage flowed into the whole harbor during a tidal cycle of 12 lunar hours. Inasmuch as about 23 per cent of the water of the harbor flowed out on the ebb tide, the same percentage of the contribution of sewage would flow to sea at the same time, leaving about 77 per cent, mixed with the harbor waters at mean low tide. The quantity of liquid sewage matter subsequently remaining within the harbor would increase with each succeeding tidal

cycle until the quantity which passed out with the ebb tide became equal to that which drained into the harbor during the tidal cycle. This would occur when the total volume of liquid sewage, remaining intermixed with the harbor waters at mean low tide had become equal to about 195,500,000 cu. ft., which it would do after about 20 tidal cycles. The volume of liquid sewage matters passing out of the harbor through the Narrows would then continue to equal the volume of liquid sewage matters flowing into the harbor during a complete tidal cycle. That is, if 59,490,000 cu. ft. of sewage passed out of the harbor with each 12,310,000,000 cu. ft. of ebbing tide, the dilution of sewage to water would be in the proportion of 1 to 200 and the dilution to the liquid sewage matters remaining in the harbor at mean low tide would be in like proportion.

Both at the beginning and end of his calculation, Prof. Adeney took pains to fully explain that this calculation did not, as no calculation could, truly represent the facts.

In a report by Messrs. Black and Phelps, made to the Board of Estimate and Apportionment of New York in 1909, the question of dilution is dealt with at length, for it was believed to have an important bearing on the question of dissolved oxygen, and the authors considered that the oxygen should not fall below 70 per cent. of the amount which would be present if the water was saturated with it.

24 The sources of the water in each principal part of the harbor were assumed in accordance with volumes and velocities stated by the Coast and Geodetic Survey in 1886, and the proportion of water from each source was apportioned by the authors as, in their judgment, seemed correct. For convenience—these volumes were reduced to percentages of the whole and each was given a characteristic letter to facilitate computation. A series of equations was derived and the composition of the water of each part of the harbor was calculated for various tidal periods.

These studies were taken by the authors to indicate that the volume of pure sea water which entered the harbor between the Narrows and Throgs Neck every 12 hours was 29.135 million gallons and that this contained under summer conditions 1,946,218 pounds of dissolved oxygen. It was considered that if this oxygen were to be reduced by sewage to 70 per cent. of saturation, 583,865 pounds would be lost in 12 hours. The total volume of water in the harbor within the limits named was taken to be 251,418 million gallons, and it was stated that if this were reduced to 70 per cent. of saturation, it would absorb in 12 hours from the atmosphere 0.95 per cent. of its saturation value of 159,550 pounds.

The oxygen absorbed from the atmosphere plus the oxygen from the pure sea water would give a total of 743,415 pounds of oxygen. Finally, assuming that the sewage would be produced at the rate of 100 gallons per capita per day, the authors arrived at the opinion that the natural supply of oxygen would be sufficient to care for the sewage of a population of 7.4 millions, provided the sewage was discharged at the two ocean entrances.

6.—Ratios of Sewage to Water.

Some calculations of the ratios of sewage to water have been made by the Metropolitan Sewerage Commission which deal with comparatively small parts of the harbor and are consequently not greatly affected by the errors which are generally inseparable from such computations. But all calculations of this kind should be regarded as crude approximations of the truth.

There are three divisions of the water with which it is of interest to compare the sewage. First, the volume of water which is contained in the vicinity of an outlet at mean low tide; second, the volume of the tidal prism or quantity of water in the vicinity between the levels of low and high tide; third, the net ebb flow past the point where the sewage is emptied.

The Metropolitan Sewerage Commission has divided New York harbor into ten sections and the quantities of sewage which were discharged directly into these sections in 1910 have been estimated; the quantities of water in each section below mean low tide, in the tidal prism, and the net ebb flow through the section have been computed and the ratio between the sewage and the water has been calculated. Calculations based on estimates of future quantities of sewage have also been made.

In addition to these computations, estimates have been made of the aggregate weight of sewage impurities which are tributary to each section. These calculations are based on a definite composition of the sewage which is assumed and taken to be uniform for the whole territory. The composition assumed is that of the standard sewage as shown in Table V. The volume of the sewage for the year 1910 is based upon the public water supply. The volume expected in future is also founded upon anticipations of the drinking water requirements. The per capita volume of sewage being stated, it will be possible at any time to correct the estimates of weight of impurities discharged into the harbor in case either the composition or volume of the sewage becomes known. It is improbable that such knowledge can be obtained until main drainage works are built.

It has seemed desirable to calculate the quantities of sewage material which would be discharged into the various sections of the harbor in case the sewage was first passed through works for the more or less complete removal of the impurities. The processes of treatment which have been thought most worthy of consideration in this connection are such as have been well established by experience. Screens are considered because of their compactness and ability to operate with varying quantities of sewage and small head. Settling basins have been included because of their almost universal employment in sewage purification works and their efficiency in removing suspended matter. Chemical precipitation has been considered because it is one of the most efficient means for removing both suspended and dissolved matter at one process. Sprinkling filters have been included, since they represent the most effective means of oxidizing the sewage impurities in a given area of land.

It would be feasible, and it is customary where a high degree of purification is required, to combine two or more of these processes in a given plant.

The least effective process which seems worth considering for the sewage which is to be discharged into the harbor is screening, and the highest degree of purification practicable in most cases in the territory where the sewage is produced in screening and rapid settlement. More purification than this would require a greater amount of land than is procurable except at great cost and involve probable nuisance from odors and flies.

Estimates of the quantities of sewage discharged into New York harbor show that all sections do not receive an equal share
26 of pollution; the analyses of the water show that the circulation of the tide is insufficient to distribute satisfactorily the excessive burden which some sections receive. Some parts of the harbor are much more polluted than others, the region of greatest pollution being close to the most densely settled part of New York City. The Lower East river and Harlem receive large quantities of sewage from both shores.

Table VI.

Volumes of Water at Low Tide, in the Tidal Prism and the Net Discharge from the Several Divisions of the Harbor. The Quantities are Expressed at Million Cubic Feet.

Division of the harbor	Volume of water below mean low tide.	Tidal prism.	Net ebb flow in 12 lunar hours.
Harlem river	285	148	15
Hudson river, Battery to Mt. St. Vincent	12,330	1,697	1,087
Upper East river	5,512	1,869	.....
Lower East river	4,174	552	100
Upper bay	12,970	2,541	1,283
Newark bay	1,542	1,071	105
Kill van Kull	728	150	88
Jamaica bay	2,029	1,977	.....
	40,971	10,033	.....

Table VI was prepared partly from tidal data computed by this commission and partly from information supplied by the United States Coast and Geodetic Survey in 1909, as a result of studies which were made in response to this commission's request.

It will be seen from Table VI that the Upper bay contains more water at low tide, has a larger tidal prism and has a larger net discharge of water than has any other part of the harbor. The Hudson river is a close second in volume at low tide, but it has a smaller

prism and net flow than the Upper bay. The tidal prism and volume of water at low tide are nearly the same in Jamaica Bay and Newark bay, from which it appears that these bodies of water are almost half renewed at each tide.

In the Lower East river, the tidal prism is one-sixth the volume of water which lies beneath the level of mean low tide and the net ebb flow is about one twenty-seventh of it. Nowhere else in the metropolitan district is the net ebb flow so small in comparison with the tidal prism or volume of water at low tide. Large as is the volume of water in this division, it is evident that there is not a great deal of
27 new water passing through it. In the Harlem also, the tidal prism is large and the net ebb flow small when compared with the volume of water at mean low tide. From these figures, it appears that such refreshing action as the Lower East river and Harlem river receive is due to diffusion with cleaner water at the two ends of these streams and that little renewal occurs by actual displacement with water from a neighboring section. Large though the Lower East river seems to be and swift as are its currents, it has only one-tenth as much net ebb flow as the Hudson.

To facilitate computations which will be described later, the quantities of sewage discharged into the several divisions of the harbor have been converted from gallons per 24 hours to cubic feet per 12 lunar hours. The results are recorded in Table VII.

TABLE VII.

Volume of Sewage Directly Tributary to the Several Divisions of the Harbor.

Division of the Harbor.	Directly tributary, million cu. ft. per 12 lunar hours.	
	Year 1910.	Year 1940.
Harlem river	6.9	17.5
Hudson river	9.2	20.9
Upper East river	1.5	6.9
Lower East river	17.1	31.5
Upper bay	4.4	8.2
Newark bay	0.9	2.1
Kill van Kull	0.5	1.6
Jamaica bay	3.7	11.3

TABLE VIII.

Ratios of the Volume of Sewage Directly Tributary per 12 Lunar Hours to the Volume of Water in the Harbor at Mean Low Tide. The Quantities Given are in Millions of Cubic Feet.

Division of the Harbor.	Water in the division.	Sewage tributary to the division.			
		Year 1910.		Year 1940.	
		Volume.	Ratio.	Volume.	Ratio.
Harlem river	285	6.9	1:41	17.5	1:16
Hudson river	12,330	9.2	1:1350	20.9	1:590
Upper East river	5,512	1.5	1:3675	6.9	1:799
Lower East river	4,174	17.1	1:244	31.5	1:132
Upper bay	12,970	4.4	1:2950	8.2	1:1580
Newark bay	1,542	0.9	1:1680	2.1	1:740
Kill van Kull	728	0.5	1:1470	1.6	1:460
Jamaica bay	2,029	3.7	1:550	11.3	1:180
	39,570	44.2	1:896	100	1:396

28 Table VIII which is prepared from data contained in Tables VI and VII emphasizes the proportionately heavy sewage burden which is now, and in future would be, placed upon the Lower East river. The ratio of sewage to water at mean low tide which was 1 to 244 in 1910 would be 1 to 132 by 1940. A notably low ratio is that of the Kill van Kull which was 1 to 1470 in 1910 and would be 1 to 460 by 1940. This body of water received much of its pollution from neighboring bodies of water. The pollution of Newark bay will increase by direct contributions of sewage until the ratio which was 1 to 1680 in 1910 will be 1 to 740 by 1940 unless measures are taken to keep the sewage out of it.

TABLE IX.

Ratios of the Volume of Sewage Directly Tributary to the Volume of Water in the Tidal Prism. The Quantities Given are in Millions of Cubic Feet.

Division of the Harbor.	Water in the prism.	Sewage tributary to the division.			
		Year 1910.		Year 1940.	
		Volume.	Ratio.	Volume.	Ratio.
Harlem river	148	6.9	1:21.4	17.5	1:8.5
Hudson river	1,697	9.2	1:185	20.9	1:81
Upper East river	1,869	1.5	1:1246	6.9	1:271
Lower East river	552	17.1	1:323	31.5	1:17.5
Upper bay	2,541	4.4	1:570	8.2	1:310
Newark bay	1,071	0.9	1:1170	2.1	1:510
Kill van Kull	150	0.5	1:300	1.6	1:94
Jamaica bay	1,977	3.7	1:540	11.3	1:175
	10,165	44.2	1:229	100.0	1:101

Table IX has been prepared from Tables VI and VII and shows the remarkably small ratios which exist between the sewage and tidal prism in most of the divisions of the harbor. The smallest ratio occurs in the Harlem, 1 to 21.4, although the Lower East river, 1 to 32.3, is very low for the year 1910. In 1940 the tidal prism will be only 8½ times the volume of sewage discharged directly into the Harlem and in the Lower East river only 17½ times the quantity of sewage received.

Unlike the ratio of sewage to water below mean low tide, the relation of sewage to the tidal prism is comparatively large in Newark bay and will be considerable in 1940. This division of the harbor, which was comparable with the Lower East river in Table VIII, resembles the Hudson river, where the pollution is, and probably will remain, large.

The quantities of water passing through each division in their relation to the volume of sewage directly discharged are shown by Table X, which was prepared from Tables VI and VII.

TABLE X.

Ratio of the Volume of Sewage Directly Tributary per 12 Lunar Hours to the Net Ebb Flow. The Quantities Given are in Millions of Cubic Feet.

Division of the Harbor.	Net ebb flow.	Sewage tributary to the division. Year 1910. Volume.	Year 1910. Ratio.	Year 1940. Volume.	Year 1940. Ratio.
Harlem river	15	6.9	1:2.2	17.5	1:0.85
Hudson river	1,087	9.2	1:119	20.9	1:52
Upper East river	.....	1.5	.....	6.9	.....
Lower East river	100	17.1	1:5.9	31.5	1:32
Upper bay	1,283	4.4	1:288	8.2	1:156
Newark bay	105	0.9	1:114	2.1	1:50
Kill von Kull	88	0.5	1:178	1.6	1:55
Jamaica bay	24	3.7	1:6.5	11.3	1:2.1
	2,702	44.2	1:61	100.0	1:27

The small amount of dilution from the net ebb flow which the sewage which was discharged into the Lower East river received in 1910 and will receive in 1940 is even more graphically indicated in this table than in its predecessors. By 1940 there will be more sewage discharged into the Harlem than there will be tidal water passing through that stream. There will be about three times as much tidal water as sewage passing out of the Lower East river. The Hudson river and Upper New York bay alone seem to be comparatively well supplied with water available for flushing purposes.

Table XI shows the number of tons of the various constituents of the sewage based on the composition shown on Page 18, and the volume shown on Page 27. It will be seen that in every important respect, the Lower East river receives a greater weight of contaminating matters than does any other division of the harbor, irrespective of its size. Next comes the Hudson river, followed by the Harlem. The total weight of sewage materials discharged into the Kill van Kull and Newark bay is small as compared with the quantities of polluting matters discharged into the Lower East river.

TABLE XI.

Solid, Organic and Volatile Matters Contained in the Sewage Directly Tributary to the Several Divisions of the Harbor. The Quantities are Expressed as Tons of 2,000 lbs. per 12 Lower Hours.

Division of the Harbor.	Year.	Suspended solid matters.	Organic and volatile matters.					
			Total.	Dissolved.	Suspended.	Nitrogenous.	Fat, etc.	Carbon.
Harlem river	1910	52	70	35	35	26	9	35
	1940	111	148	74	74	56	18	74
Hudson river	1910	65	87	43	44	33	11	43
	1940	126	168	84	84	63	21	84
Upper East river	1910	12	16	8	8	6	2	8
	1940	43	57	29	28	21	7	29
Lower East river	1910	133	178	89	89	67	22	89
	1940	209	279	139	140	105	35	139
Upper bay	1910	34	45	23	22	17	6	23
	1940	59	79	40	39	30	10	40
Newark bay	1910	7	9	4	5	3	1	4
	1940	13	18	9	9	7	2	9
Kill van Kull	1910	3	4	2	2	2	0.6	2
	1940	9	12	6	6	4	2	6
Jamaica bay	1910	23	30	15	15	11	4	15
	1940	59	79	39	40	30	10	39
Total	1910	329	439	219	220	165	55.6	219
	1940	629	840	420	420	318	105	420

Table XII, which has been prepared from Table V and VII, shows the weight of sewage ingredients which will be discharged into the harbor in 1910 and 1940, assuming that the sewage is first passed through certain forms of treatment with the object of removing impurities. The efficiency of the treatment employed has been assumed as follows: The screens remove 15% of suspended matter and 10% of organic matter; sedimentation 60% of suspended matter and 30% of organic matter; chemical precipitation 85% of suspended matter and 50% of organic matter; sprinkling filters 90% of suspended matter and 70% of organic matter.

It will be observed that the use of any of these processes would be beneficial, but that the residue to be discharged after screening or sedimentation would still leave very large quantities of pol-
31 luting matter to go into the water. Chemical precipitation and the use of sprinkling filters would probably furnish all the relief needed for as many years as can now be anticipated. As has been shown elsewhere in this report, however, these latter processes are not applicable unless the sewage is carried to some point far removed from its present source for treatment.

Table XII.

Suspended and Organic Matters which Would be Contained in the Sewage Directly Tributary to the Several Divisions of the Harbor After Treatment. The Quantities Given are in Tons per 12 Lunar Hours.

Division of the Harbor.	Year.	Crude sewage.		Sewage after treatment.							
				Screens.		Sedimentation.		Chemical precipitation.		Sprinkling filters.	
		Sus.	Org.	Sus.	Org.	Sus.	Org.	Sus.	Org.	Sus.	Org.
Harlem river	1910	102	70	44	63	21	49	7.8	35	5.2	21
	1940	111	148	94	133	44	104	16.6	74	11.1	40
Hudson river	1910	65	87	35	78	20	61	9.8	44	6.5	26
	1940	136	168	107	151	50	118	18.9	84	12.6	50
Upper East river	1910	12	16	10	14	5	11	1.8	8	1.2	5
	1940	43	57	37	51	17	40	6.4	28	4.3	17
Lower East river	1910	133	178	115	160	53	125	20.0	89	13.3	53
	1940	200	279	178	251	84	195	31.4	140	20.9	84
Upper bay	1910	34	45	28	40	14	32	5.1	22	3.4	13
	1940	50	79	50	71	24	55	8.8	39	5.9	24
Newark bay	1910	7	9	6	8	3	6	1.0	4	0.7	2
	1940	13	18	11	16	5	13	2.0	9	1.3	5
Kill van Kull	1910	3	4	3	4	1	3	0.5	2	0.3	1
	1940	9	12	8	11	4	8	1.4	6	0.9	4
Jamaica bay	1910	23	30	20	27	9	21	3.4	15	2.3	9
	1940	30	79	50	71	24	55	8.8	40	5.9	24
Total	1910	379	439	280	394	132	308	49.4	219	32.9	131
	1940	628	840	535	755	252	588	94.3	420	62.9	252

7.—Possible Methods of Sewage Treatment.

Early studies made by this commission indicated that excluding from the harbor as much sewage matter as practicable from those parts of Queens, Richmond, Brooklyn and the Bronx which are tributary to the Upper East river and Upper and Lower New York bays, by the employment of local purification works, the water of the inner harbor would be able to assimilate the sewage from those parts of Manhattan and Brooklyn which were closely built up and where sites could not readily be obtained for the construction of purification works of high efficiency. In this belief plans were begun
for collecting the sewage of the Bronx, Queens and Rich-
32 mond and gathering it to a number of conveniently located
central points for treatment.

Two immediate objects were to be attained by these plans. First, the harbor water in those divisions where the works were located was to be kept clean, and, second, the water was to be protected to such an extent as to insure to the inner harbor the largest assimilative capacity practicable.

As the plans progressed, it became evident that a high degree of purification could not be obtained for as much of the sewage as had been expected. To remove a large proportion of the putrescible material from sewage requires works which could not always be situated where engineering considerations alone would have placed them. In such cases land must be procurable at a price which does not unduly increase the first cost of the project. Of equal importance, it is necessary to locate such works in positions where the odors produced will not injure property to such an extent as to give owners of surrounding land valid claims against the city for damages.

Odors from Efficient Processes.—It is needless to deny that all processes of sewage purification cause smells. The fact should plainly be faced that in the removal the ingredients of sewage which are capable of causing the water into which the sewage is discharged to become offensive, objectionable odors may be produced at the works. The danger of nuisance depends partly upon the degree of thoroughness with which the impurities are removed and partly upon the likelihood that the property holders in the vicinity will find the odors seriously objectionable. There are localities in the City of New York and vicinity where objectionable odors are continually produced by manufacturing establishments with little or no complaint from property holders. But these situations are not usually well placed for sewage disposal plants, and it is doubtful of the city would be justified in adding to these odors even if it became otherwise desirable to construct sewage works there. Manufacturing plants which are objectionable, such as slaughter-houses, bone-boiling establishments and fertilizer factories, usually have to move further and further away, as the cities in which they are located grow. Nuisances of this kind become increasingly objectionable as time proceeds, for more and more people become affected and the public becomes increasingly fastidious.

Such strong and offensive odors as are produced by so-called offen-

4513

sive trades are not likely to be produced by sewage works, but the difference is sometimes not great, and the erroneous belief that sewage odors are in some way connected with disease, if not actually a cause of it, adds greatly to the objectionableness of sewage purification plants in any locality.

33 A convenient and economical location for sewage works is hampered by the uncertainty that they will be permanent. Unlike some manufacturing plants, they cannot well be moved in case they produce a nuisance. If they are objectionable at first, they are likely to become more so with the passage of time. Owing to the protest with which a proposal to build a municipal plant for the thorough treatment of sewage probably would be received in almost any part of New York City, this commission has felt compelled to confine its plans largely to works of the simplest character or carry the sewage to a distant point for disposal. In the selection of sites, considerable difficulty has been experienced because of the changing character of many localities. Few parts of New York are permanently constructed. Solidly built-up sections are constantly changing from residence to business occupancy. Suburban districts are rapidly becoming urban, and rural territory is being converted to suburban uses. Each change increases the value of the land. The most rapid developments, and the most uncertain, are sometimes in the very localities where it would be most convenient to build sewage disposal works. Here unimproved property, even farm land, is not infrequently held at a high valuation in the expectation that a strong demand for real estate may set in at any time.

Owing to the facts here mentioned, this commission has not found it feasible to design works which would purify the sewage tributary from the outlying territory to a high degree, and the water which will reach the inner harbor will consequently not have as great a capacity for assimilating sewage as theoretically it should possess.

What is here said as to the nature of the works which it has been feasible to design for Queens, Richmond and the Bronx applies with greater force to the Lower Hudson, Lower east River and Bay Division. The aggregate volume of sewage produced in this division is now great, and thirty years hence will be about double what it is today. Such treatment as it is practicable to accomplish within the territory where this sewage is produced will remove only a small proportion of the ingredients which are capable of reducing the amount of oxygen in the water into which the effluent is discharged. Sprinkling filters, contact beds, sedimentation basins and chemical precipitation plants, cannot be considered for want of land and because of the odors which such works would produce.

The forms of treatment which could be best employed on the shores of Manhattan and Brooklyn would be such as could be carried on with grit chambers and screens.

Grit Chambers and Screens.—In some respects grit cham-
34 bers and screens are well suited to the conditions. Beside being compact, they produce little odor; they can be located partly below ground; they require no extra pumping; they are comparatively inexpensive to operate; they can be employed without

highly skillful supervision, and it is practicable to have many plants of moderate capacity. Against them is chiefly the criticism that they remove only the largest particles of sewage matter and leave the dissolved organic matter and finely divided putrescible materials to pass to the harbor. Notwithstanding this fact, they would serve usefully in attaining the standard of cleanness which the Metropolitan Sewerage Commission has proposed for the water, particularly as respects requirements Nos 1 and 3 of the standard. This standard follows:*

1. Garbage, offal or solid mater recognizable as of sewage origin shall not be visible in any of the harbor waters.

2. Marked discoloration or turbidity, due to sewage or trade wastes, effervescence, oily sleek, odor or deposits, shall not occur except perhaps in the immediate vicinity of sewer outfalls, and then only to such an extent and in such places as may be permitted by the authority having jurisdiction over the sanitary condition of the harbor.

3. The discharge of sewage shall not materially contribute to the formation of deposits injurious to navigation.

4. Except in the immediate vicinity of docks and piers and sewer outfalls, the dissolved oxygen in the water shall not fall below 3.0 cubic centimeters per litre of water.†

Near docks and piers there should always be sufficient oxygen in the water to prevent nuisance from odors.

5. The quality of the water at points suitable for bathing and oyster culture should conform substantially as to bacterial purity to a drinking water standard. It is not practicable to maintain so high a standard in any part of the harbor north of the Narrows or in the Arthur Kill. In the Lower bay and elsewhere, bathing and the taking of shellfish cannot be considered free from danger of disease within a mile of a sewer outfall.

Inasmuch as grit chambers and screens seem to afford the best practicable means available for treating the sewage of Manhattan and Brooklyn locally, it is desirable to consider in some detail how such works would be constructed, how many plants would be required, about where they should be built, what they might cost and how much improvement they would accomplish. In studying these questions, two chief considerations have appeared to be important. First, the outlets from the works should be so built that the treated sewage will be promptly and thoroughly diffused, and Second, the plants should be so located as to permit the sewage to be collected to them without unnecessary difficulty or expense.

Submerged Outfalls.—Owing to the incompleteness of the purification, and the necessity of complying with requirement No. 2 of the

*Report Metropolitan Sewerage Commission of New York, August, 1912, page 70.

†With 60 per cent. of sea water and 40 per cent. of land water and at the extreme summer temperature of 80 degrees F., 3.0 cubic centimeters of oxygen per litre corresponds to 59 per cent. of saturation.

Standard of Cleanness, it would be necessary to discharge the
35 effluent from the plants in such a way as to produce the most immediate disappearance of the sewage which is possible. For this purpose, it is desirable that the outfalls should be near or upon the bottom and be so located that ample and strong currents will sweep by them.

The construction and maintenance of outlets at the bottom of the tidal channels some distance from shore would be difficult. The outlets would have to be so built as to meet all the requirements of the United States Government which has supervision over the maintenance of the channels for the purposes of navigation.

Locations for Outlets.—Bearing in mind the difficulties of construction and maintenance, as well as the advantages of carefully selected places, a number of points have been chosen along the shores of Manhattan and Brooklyn where the sewage, after treatment, could with the greatest advantage be discharged.

The facility with which the sewage could be collected to suitable points for treatment was taken carefully into consideration in selecting the points of outfall. It was thought desirable that the sewage should require the least amount of pumping possible; that the plants should not have to be placed too far below tide level and that the greatest possible normal flow of sewage should be gathered to each plant.

Considerable care has been taken in the designs to make an economical use of land, to provide for adequate inspection and repair, not only of the apparatus, but of the structure itself, to insure light and ventilation and to facilitate the cleaning of the basins and screens and the removal of the impurities from the plant. Numerous forms of grit chambers have been designed and studied. Every form of screen which the experience of other cities had proved reliable and efficient have been considered with the result that the type employed in the new works at Hamburg, Germany, was chosen as the most suitable for these works.

8. Plan for th Disposal of the Sewage of this Division.

Investigation having shown that it will be impossible to discharge all the sewage into the water in the vicinity of the territory where it is produced, even after such purification as is practicable, it becomes necessary to consider where it can be taken and what can be done with it.

Amount of Sewage to be Taken Away.—It will not be worth while to take a small amount of sewage from the inner harbor. To accomplish much benefit, the volume will have to be large both actually
and in relation to the total quantity produced in this division.
36 If possible, it should be taken from a part of the harbor which needs relief both on its own account and because of its influence on adjoining sections. As far as practicable, the sewage should be collected from a region of dense population in order that the length of the sewers shall be no greater than necessary. For the

same reason the distance from the central point of collection to the point of disposal should be as short as possible.

This report shows that the greatest burden of pollution which is placed upon any large portion of the harbor is discharged from Manhattan and Brooklyn into the Lower East river. Here within a distance of 4 miles, about 200,000,000 gallons of sewage are discharged every 24 hours from about 50 outlets located along the crowded shores. Not only is the volume of sewage large, but, as shown elsewhere in this report, the waters are peculiarly unsuited to receive it.

If this polluting material can be removed, the waters in the immediate vicinity will be improved and the excessive burden of pollution now put upon the whole inner harbor will be relieved. An improvement of the waters of the Lower East river is desirable for the help it will give in disposing of the sewage which, in accordance with the commission's plans already announced, will be brought to Ward's Island.* At Ward's Island the large quantity of sewage which will be brought from the Harlem river will be passed through settling tanks and discharged into the deep waters of Hell Gate, and reliance must be placed upon the digestive capacity of the waters to oxidize the liquid organic matters.

If 200,000,000 gallons of sewage per day can be kept out of the Lower East river, the ratio of sewage to water in that section will improve sufficiently to meet all requirements of this commission's standard of cleanness for the present. The ratios of water to sewage which will exist in the Lower East river are given in Table XIII.

TABLE XIII.

Ratios of Sewage to Water in the Lower East River, if 200,000,000 Gallons of Sewage per Day Are Kept Out of these Waters.

Year.	Sewage to water at low tide.	Sewage to tidal prism.	Sewage to net ebb flow.
1910	1 to 1090	1 to 204	1 to 30
1940	1 to 178	1 to 33	1 to 5.6

Direction in which to Take the Sewage.—There are not many directions in which the sewage can be taken. It would be impracticable to carry it north into Westchester County, for the land there lies at too great an elevation. It would be impossible to carry it west because the people of New Jersey would object to receiving it. The idea of discharging it into the Hudson river cannot be entertained, for if this were done that stream would become too heavily polluted. Sentimental considerations require that the Hudson shall not be made a receptacle for the sewage from other parts of the harbor.

37

It would not be feasible to carry the sewage to Long Island sound;

* Preliminary Report IV. Study of the Collection and Disposal of the Sewage of the Upper East River and Harlem Division, July, 1912.

the distance would be too great, the volume of water there available would be insufficient, the danger of polluting extensive shellfish beds would be large, and the risk of contaminating the shores in the vicinity of villages, towns and country estates too imminent.

The sewage could not be taken east on Long Island, except to a distance of 30 or 40 miles, for its disposal would be certain to produce nuisance and, consequently, serious injury to property already occupied for residence purposes or likely soon to become valuable for this purpose. Furthermore, opportunities for the disposal of the effluent of treatment works are lacking on Long Island, the north shore of which is deeply indented with bays and, for the most part, high and rocky, and the south shore bordered with broad, shallow bays and marshy islands, where the flow of tidal water is relatively slight.

Staten Island Not Suitable for Very Large Sewage Works.—To the southwest of this division lies the Borough of Richmond, or Staten Island, and much sewage could be brought there for treatment as far as engineering considerations are concerned. There are several thousand acres of marshy land on the west side of this island bordering the Arthur Kill which might be employed for sewage disposal, provided no nuisance was produced.

The sewage could be taken to the disposal works by a tunnel which could be driven beneath the waters of Upper New York bay to the north shore of Staten Island, and thence through the high land to the low-lying area near the Arthur Kill. The Arthur Kill has been dredged for the convenience of ships and could receive a well purified effluent, although owing to its small volume of flow and the oscillating effect of the tide, the capacity of the Arthur Kill for unpurified sewage is comparatively small. If the sewage could not be purified sufficiently to discharge the effluent into the Arthur Kill, it would have to be carried by tunnel eastward from the treatment works to the waters of Lower New York bay.

It is probable that treatment works capable of purifying the sewage to such an extent as would permit the effluent to be discharged into the Arthur Kill would be impracticable on Staten Island. Apparently some oxidizing process, either sprinkling filters or possibly contact beds, would have to be employed. It is probable that
38 if either of these processes were used to treat the quantity of sewage which would have to be dealt with, not less than 200,000,000 gallons per 24 hours, with a certainty of more later on, objectionable sanitary conditions would be produced. The sewage would be septic and, consequently, likely to produce odor when brought into contact with the air either in the fine spray necessary in sprinkling filters or in the large areas of surface exposed by the broken stone of contact beds. The likelihood of trouble from flies, a frequent any annoying feature in sewage works, should also be considered. The peculiar mist which sometimes hovers in calm weather over extensive areas of sprinkling filters would prove a source of gave concern to property holders, even at a considerable distance from the works. Before the authorities of the Borough of Richmond would give their consent to receiving the sewage of this division in

that borough for disposal, it is probable that they would insist upon more assurance of immunity from nuisance than safely could be given.

Added to the sanitary difficulties which would attach to the disposal of the sewage by works upon Staten Island is the consideration of cost. It would be expensive to carry the sewage of this division to Staten Island and there dispose of it. The tunnels would be long and, in places, very deep. The foundations for the works on the lowlands in the western part of Staten Island might prove difficult of construction. The outlet tunnel for the effluent would be long and costly.

Objections to Collection at Barren Island.—Two other possible means of disposing of the sewage of this division remain to be considered. First, collection to the vicinity of Barren Island, near the mouth of Jamaica bay, and treatment there, with a discharge of the effluent at sea. Sanitary considerations, such as have been mentioned in connection with the possibility of carrying the sewage to Staten Island, would weigh heavily against purifying the sewage any more completely than is absolutely necessary at this point. The outlet would therefore have to be long enough to carry the sewage far from shore.

Unless the sewage was purified in bacteria beds, it would be necessary to extend the outlet some miles out to sea beyond Rockaway Point in order to make sure that the sewage would not be carried back to the land by the wind and tide, and there are practical difficulties in the way of doing this. The necessary tunnel for this purpose would be very difficult to construct. It would have to be at least 75 feet below the surface of the water, in order to cross well beneath the deep, swiftly-flowing channels of Rockaway inlet. The water at this point is between 30 and 40 feet deep at low tide. Proceeding seaward it would not be found desirable to approach much nearer the surface with it. The point of outfall should probably be
39 located about 2 miles from shore. This would be an unfavorable location for an outlet crib or other permanent structure, for it would be exposed to the full force of the Atlantic ocean and the shifting sands. This project thus has weighty arguments against it.

Advantages of Disposal at Sea.—The sewage from the Lower East river section can be taken directly to the sea, and this is the plan which the commission recommends. In accordance with this plan, central collecting points will be established which will be tributary to a general central station, to which latter point will be gathered such part of the sewage as needs to be carried to a distance. Pumps will be located at the central station and from it a main will run directly to an outfall island to be built about 3 miles from land on a sandy reef. This reef is one of a series of shallow areas, interspersed with channels, which once formed the bar to New York harbor. It lies slightly to the west of an imaginary line between Sandy Hook and Rockaway Point. The outfall will be about 13 miles from the New York City Hall, 6 miles from the Narrows, over 4 miles from Sandy Hook and about 3 miles from Coney Island. The point selected for this island is shown in Plate I, following page 48.

As much sewage as it is necessary to carry to a distance from the Lower East river, Hudson and Bay Division can be taken to the island for disposal. As time proceeds and the quantity of sewage increases, the main sewer can be duplicated and the provisions for treating and discharging the sewage at the island can be enlarged.

A large part of the sewage of this division is now discharged into the waters of the Lower East river. If this sewage is taken away for disposal, it will for some time be possible to discharge the sewage from the rest of the division with no other treatment than screening and passage through grit chambers. The water of the Hudson will be capable of assimilating the sewage produced on the west side of Manhattan Island and the water of the Upper bay could take the sewage produced along the Brooklyn water front from Governors Island southward.

All the sewage from this division, except that part which is taken away, should be passed through grit chambers and screens and, where feasible, the dry weather flow discharged through submerged outlets. In course of time, if the quantity of sewage from this division, as well as from that part of the Upper East river and Harlem Division which would be concentrated at Ward's Island, increases to such an extent as again to place an excessive burden upon the waters of the East river, the sewers can be extended and finally the Ward's Island works can be connected with a main sewer to the artificial island for disposal.

40 The plan of relieving the harbor of its heaviest burden by at once taking to sea a large part of the sewage which flows to the Lower East river and increasing the scope and magnitude of the work as necessity arises, appears to this commission to be a necessary and sufficient solution of the problem. In no other way can the sewage be disposed of with so little chance of danger or offense. The project has the advantages that it will afford, at minimum expense, all the relief that is needed for the present and is capable of expansion in the future.

There are no selfish industries in the vicinity and no currents which would carry any of the sewage to a bathing beach. The sewage will not be exposed long enough to the air to cause annoying odors to be given off and there will be no opportunity for flies to breed.

The plan is in accordance with the best engineering precedent. There is no feature connected with it which is untried or experimental. It avoids offensive, complicated and uncertain processes of purification. It is based upon a careful consideration of the needs of the whole harbor. It leaves the waters of the inner harbor in a sufficiently improved condition for the assimilation of such sewage as cannot be kept out of the waters without wellnigh prohibitive expense.

Ultimate Digestion by the Sea Water.—The project for carrying a part of the sewage to sea contemplates the treatment of the sewage at the island and the ultimate digestion of the liquid organic matter of the sewage by the sea water. Responsibility for the disposal

of the sewage cannot cease until all the ingredients are rendered harmless and inert. It is important that the sewage shall not flow from the outlets as a coherent mass and that none of its elements shall be carried to the inner harbor or find their way, under the influence of wind or tide, to the shore. Accumulations of solid matter injurious to navigation must not be permitted to occur, nor must odors or flies or other objectionable features too commonly associated with sewage disposal works exist to mar the natural attractiveness and healthfulness of that part of the ocean where the outlet is located.

The liquid sewage matters will have a strong avidity for oxygen and will be rendered inert by the oxygen-saturated sea water with which it comes in contact. The great amount of water available at the point of outfall will have an abundant capacity to digest the liquid sewage.

At first the form of treatment needed at the island will be settlement in tanks perhaps aided at times by precipitants. In addition, it may be practicable to disinfect the sewage and produce a considerable amount of oxidation by the addition of bleach or electrolytically produced hypochlorite.

If at any time in the future it becomes desirable to completely purify the sewage, no such favorable location for the necessary
41 works can be found in the metropolitan district than this artificial island. Owing to the shallowness of the water and the ease with which filling can be obtained, land can be made here for less money than an equal area can be bought on shore at any point not more distant from the New York City Hall.

In addition to the sewage from the Lower East river section, it will ultimately be feasible and desirable to send the sewage of the western Jamaica bay sub-division to the island for disposal. This would make it unnecessary to construct treatment works at Barren Island as proposed in an earlier report of this commission*

9.—Collecting the Sewage to the Outlet Island.

Sub-division of the Territory.—The territory included in the Lower Hudson, Lower East River and Bay Division has been separated by this commission into 32 sub-divisions for the purpose of laying out the works which will be necessary for the sanitary disposal of the sewage, and each sub-division has been given a number. The sub-divisions numbered 1 to 12, inclusive, comprise that part of Manhattan which is naturally tributary to the Hudson river. Sub-divisions from 13 to 26 are in Manhattan and Brooklyn, bordering upon the Lower East River. Sub-divisions 27 to 31 are in Brooklyn and border on the Upper bay. Sub-division 32 borders on the Narrows and Gravesend bay.

The sub-divisions vary in size and in quantity of sewage which they produce. The boundaries which have been approximately established are intended to show the limits within which it will be feasible to collect the sewage to a central point on the water front in each

*See Preliminary Report III.

sub-division. The central points are usually near existing large sewers and, as often as practicable, at places which are favorable for a prompt admixture of the sewage effluent with the harbor water.

As stated elsewhere in this report, the dry-weather flow of sewage, after collection to a central point in most of the sub-divisions, should be passed through grit chambers and screens and so discharged into the water as to insure prompt diffusion.

The dry-weather flow of sewage produced in the six following sub-divisions bordering upon the Lower East river should not be discharged into the neighboring waters, but should be gathered to a central point and thence carried to sea: In Manhattan, 13, 14 and 15, and in Brooklyn, 24, 25 and 26.

The method of collection in those subdivisions from which the sewage is to be carried to a distance may or may not be the same as in those sub-divisions from which the sewage will be discharged into the neighboring waters. There are various ways in which
42 the sewage can be collected. One method may be described by way of illustration.

The dry-weather sewage can be collected by marginal sewers to a central point in each sub-division and there passed through grit chambers and screens. Passing beneath each central collecting point will be a deep-lying intercepting sewer which will receive the sewage after it passes through the screens and grit chambers. Storm water in excess of twice the dry-weather flow will pass by overflows at each outlet directly to the river. Further details of this plan follow.

The Necessary Marginal Sewers and Interceptors.—Each central collecting point will have storm overflows, regulators and tide gates so arranged as to discharge directly into the neighboring waters the excess flow of sewage during periods of rainfall. The interceptors are intended to be large enough to accommodate twice the mean rate of flow during periods of dry weather. The maximum rate of dry weather flow is assumed to be about one and one-half the average rate per 24 hours. This will permit the interceptor to carry off some of the first flush of storm water even if it reaches the plant during the hour of maximum sewage production.

The marginal sewers required to collect the sewage from the present sewers to the central points in each sub-division will lie as close to the surface of the ground as physical conditions permit.

The interceptors will be situated at a considerable depth and be so located as to avoid as far as possible difficulties of construction. It will probably be necessary to construct the interceptors by shield tunneling. In making the plans and estimates, careful attention has been given to the information available concerning the geology of the territory passed through as determined by borings made by the Public Service Commission, Board of Water Supply and others.

The Manhattan Lower East Side Sub-divisions.—The interceptor from sub-division 13 will run from a screening plant situated near Roosevelt St. parallel to the shore to Corlears Hook, where the sewage will empty into a siphon and be carried to Brooklyn. This South Manhattan interceptor will be 5′ 9″ in diameter.

A second interceptor, which may be termed the North Manhattan

interceptor, will run from East 14th St. southerly to a siphon to Brooklyn which begins at Corlears Hook. The size of the North Manhattan interceptor will be 9′ 6″ from the screening plant for sub-division 15 to the screening plant for sub-division 14 at De Lancey Slip, where it will increase to 10′ 10″ in diameter before joining the siphon. The North Manhattan interceptor will be large
43 enough to permit an extension to be made in it, so as to take in the sewage of sub-divisions 16, 17 and 18 in course of time. Profiles of the Manhattan marginal sewers and interceptors are shown on Plate II, following page 48.

The total quantity of sewage to be taken from sub-divisions 13, 14 and 15 is estimated at 99,000,000 gallons per 24 hours in the year 1915. The estimated population for the same year is 680,500, and the area from which the dry-weather flow will be taken is 1,737 acres.

The Siphon from Manhattan to Brooklyn.—A siphon will be required to carry the sewage from Manhattan to Brooklyn beneath the lower East river. The point selected for the crossing is at a narrow part of the river where solid rock may be anticipated. The siphon which will be required to take the sewage produced in 1915 should have a diameter of 8′ 9″. The depth will be 110 feet beneath the surface of mean low water. The siphon will be 2,300 feet long and extend from Corlears Hook to South 8th St. When the North Manhattan interceptor is extended so as to take the sewage from sub-divisions 16, 17 and 18, it will be necessary to build a second siphon. This can be laid parallel to the first. It is desirable that the siphons needed at first shall not be too large, in order that the velocity of flow may be sufficient to prevent deposits taking place. The velocities considered suitable for the first siphon range between 2 and 5 feet per second.

The Brooklyn North Western Sub-divisions.—That part of Brooklyn which will be tributary to the main sewer to the sea will be treated in a way similar to that described for collecting the sewage from the lower east side of Manhattan. The quantity of sewage to be taken from this part of Brooklyn will be a little larger than the quantity from Manhattan, or about 104,000,000 gallons per 24 hours in 1915. The estimated population tributary in Brooklyn will be slightly larger, or 732,313, and the net area more than three times as large, or 5,790 acres.

The siphons from Manhattan will empty into an interceptor on the Brooklyn shore which will run from a central collecting point at South 5th St. for sub-division 24 to a general pumping station at Wallabout St., near the head of Wallabout canal. This interceptor will be 5′ 3″ in diameter before meeting the siphon and 10′ 3″ from the junction with the siphon to the pumping station. This may be termed the North Brooklyn interceptor. In course of time, if it becomes necessary to bring the sewage of sub-divisions 19, 20, 21, 22 and 23 to the general pumping station, this can be done by running another interceptor to the central collecting points in those sub-divisions. It appears to be unnecessary to make further provision for the future at the present time.

44 From sub-division 26 in Brooklyn, which is opposite the lower end of Manhattan, an interceptor should be built to the general pumping station. The central collecting point in sub-division 26 will be near Adams Street and the interceptor leading therefrom should be 4′ in diameter. This is estimated to be of sufficient size to take the flow from sub-division 27 in the future. At Hudson Street, this interceptor would receive the sewage collected from sub-division 25. Running around the Brooklyn Navy Yard, this South Brooklyn interceptor should have a diameter of 9′ 6″ to the general pumping station. Profiles of the Brooklyn marginal sewers and interceptors are shown on Plate III, following page 48.

The General Pumping Station.—The sewage collected at the general pumping station, amounting to about 200,000,000 gallons a day, will have been passed through grit chambers and screens and will be in reasonably fresh condition. It will all flow to this point by gravity. The pumps will be required to raise the sewage from an elevation of about 27 below mean tide and pump it under a head of about 45 feet to the artificial island at sea. The distance to be pumped will be about 11.8 miles and the head to be overcome will be that which is necessary in order to raise the sewage from the level at which it is delivered to the pumps to the level of the tanks where it is to be treated on the island, plus the head required to overcome the frictional resistance offered to the passage of the sewage through the long main. The pumps can be operated by steam, oil or by purchased electric current. It would seem feasible and desirable to drive the pumps with electric power to be obtained from burning the solid refuse of the city in destructors, as is commonly done in England and in certain large cities of Europe.

The Sewage Main to Sea.—The force main through which the sewage will be pumped to the island will be built, for the most part, in tunnel. There will be three shafts, so situated as to permit the work of construction being pushed with expedition and economy. The internal diameter of the completed main will be 12′ 10″ from the pumps to a point near Sheepshead bay, where it will be increased to 14′ in order to accommodate the sewage from the western part of the Jamaica Bay Division. A profile of the outfall main is shown on Plate IV, following page 48.

The estimates given below are based upon the work already outlined, but since the sewage main will pass comparatively near Jamaica bay, it may be desirable to modify the plan which this commission proposed for the Jamaica Bay Division* to such an extent as to permit the main to take to the island the sewage which it has been proposed to collect from Brooklyn to Barren Island for
45 treatment and disposal. The advantages to be gained by this change are (*a*) reduction in cost over the Barren Island project and (*b*) avoidance of the necessity of constructing a sewage disposal plant at the entrance of Jamaica bay. By adding the sewage of the western Jamaica bay sub-division to the sewage of Manhattan and Brooklyn which is pumped to the island, the disposal works will

* Preliminary Report III, November, 1911.

be centralized and questions of administration and maintenance will be simplified.

The Western Jamaica Bay Sub-division.—The sewage from the western part of the Jamaica Bay Division will be collected at two central pumping stations, one at Hendrix Street and the other at Flatlands Avenue. From the eastern pumping station, an interceptor 9′ to 9′ 6″ in diameter will extend for 2.6 miles to a second pumping station at Flatlands Avenue. From this point the interceptor, enlarged to 11′ 4″ in diameter, then 11′ 8″ and finally to 12′ in diameter will extend to Nostrand, where it will be joined by a small interceptor of 27 inches from the present sewage disposal works for Sheepshead bay which will be converted into a pumping station. The interceptor enlarged to 12′ 4″ will end at a pumping station to be located at Ocean Parkway and Avenue W. This last pumping station will discharge the sewage into the main which runs to the island.

A pumping station to be located at 86th Street and Avenue V in Bensonhurst will discharge through a 4′ interceptor to the pumping station which will serve the western part of the Jamaica Bay Division. The sewage of Coney Island will be pumped from the present plant known as Caisson No. 3 directly to the main sewer.

The quantity of sewage from the western part of Jamaica bay will be about 47,000,000 gallons per day in 1915. The population will be about 343,000 and the area served 19,000 acres.

The Artificial Island.—The tunnel to the island will be 14′ in diameter and constructed at a depth of about 60 feet, the material to be penetrated being sand. It will be possible to construct the tunnel with two headings, one from the shore and one from the island, the two meeting and being properly joined.

The point selected for the island has been carefully chosen with reference to economy of construction, resistance to the destructive influences of tidal currents and storms, freedom of obstruction to the free flow of tidal water in and out of the harbor and absence of sanitary objections.

The location lies to the north of Sandy Hook and to the south of Coney Island. Its position is latitude 40 degrees 31½ minutes and longitude 73 degrees 58½ minutes. The water within a mile from the island in all directions varies between 7 and 40 feet in depth, the average being about 20 feet at mean low tide.

46 The plan of the island is approximately rectangular, the seaward side being rounded. The area at the start will be about 20 acres. This can be extended as required. The general plan of the island is shown on Plate V, following page 48.

The outer face of the island will be a wall of rip rap composed of large pieces of broken stone carried to the site on boats and laid upon the hard sandy bottom. It is expected that some settlement will occur, due to the water cutting sand away from under the stone. When sufficient rip rap has been placed to stop this action of the water, no more settlement is to be expected. The main bulk of the island will be composed of sand supplied from a suction dredge, which will take its supply from the bottom of the sea in the vicinity.

The height of the island above mean low water will be about 18 feet. The length will be 1,300 feet and the width 1,000 feet. The side of the rip rap wall which is exposed to the sea will have a slope of 1 vertical upon 3 horizontal and the other sides will have a slope of about 1 on 2. The cost of constructing the island has been estimated at about $615,000.

The landward side of the island will be provided with a quay wall for the accommodation of vessels engaged in taking supplies and other materials to and from the island. Shelter from the sea will be provided by a breakwater, which will enclose a small harbor.

The island will contain a plant of settling tanks in which the sewage will have an opportunity to deposit its solid matters during a period of about two hours. These tanks will be of modified Dortmund tank construction, similar to those recently constructed at Toronto, Canada. Provision will be made for treating the sewage if necessary with a coagulant before passing it into the tanks.

After treatment, the sewage will be discharged through a number of outlets arranged radially on the seaward side of the island. If desirable, it will be feasible to pump sea water into the sewage and provide for the mixture of the two before the discharge takes place. Such admixture would facilitate the immediate diffusion of the sewage in the sea water, but the active agitation and free movement of the great volume of water in the vicinity of the island will probably make the preliminary admixture of sea water and sewage by pumping unnecessary.

The material which settle- out in the tanks will be carried to sea in boats and dumped.

Cost.—This project will require the construction of about 5.3 miles of marginal sewers in Manhattan and Brooklyn and about an equal length of interceptors in these two boroughs. The siphon from Manhattan to Brooklyn will be a little less than a half mile long. The main from the pumping station to the island will be about 13 miles long. If the Jamaica bay sewage is brought to the island, about 2 miles of collectors and 7 miles of interceptors will be required in addition.

47 & 48

Th studies which have been made indicate that the total cost of construction would be about $22,874,000, including $4,072,000 for the Jamaica Bay Division. The fixed charges, including sinking fund and interest, would be about $1,157,000, allowing $206,000 for the Jamaica Bay Division. The total maintenance and fixed charges would amount to about $1,803,000, including $286,000 chargeable to the Jamaica Bay Division.

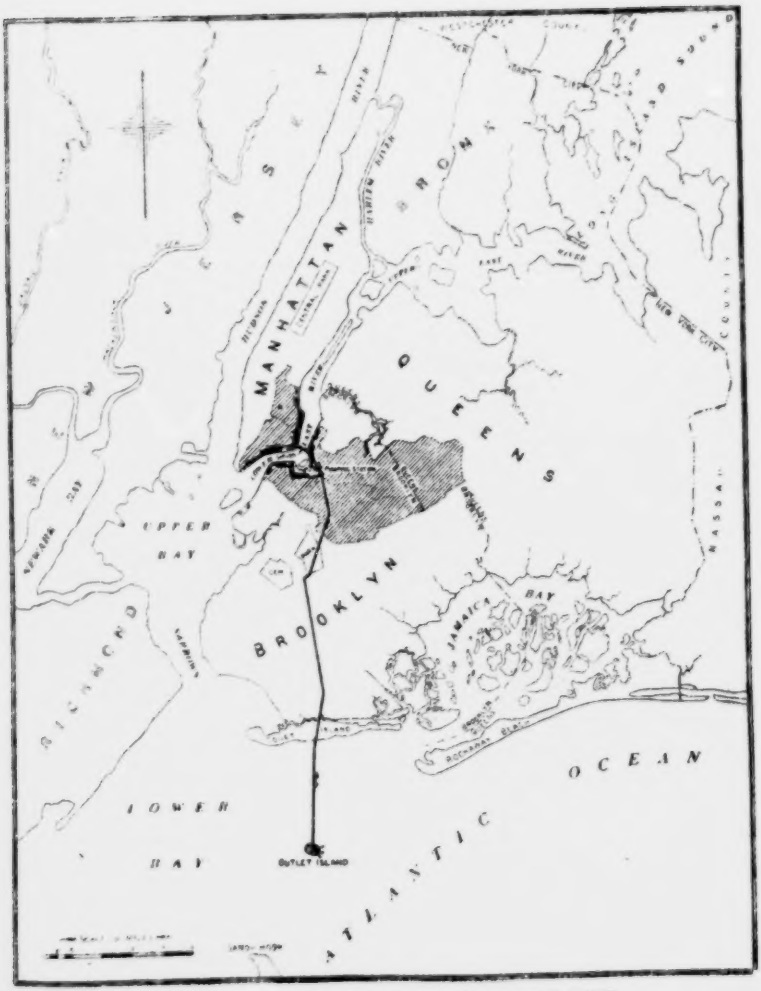
METROPOLITAN SEWERAGE COMMISSION.
GEORGE A. SOPER,
JAMES H. FUERTES,
H. DE B. PARSONS,
CHARLES SOOYSMITH,
LINSLY R. WILLIAMS.

February, 1913.

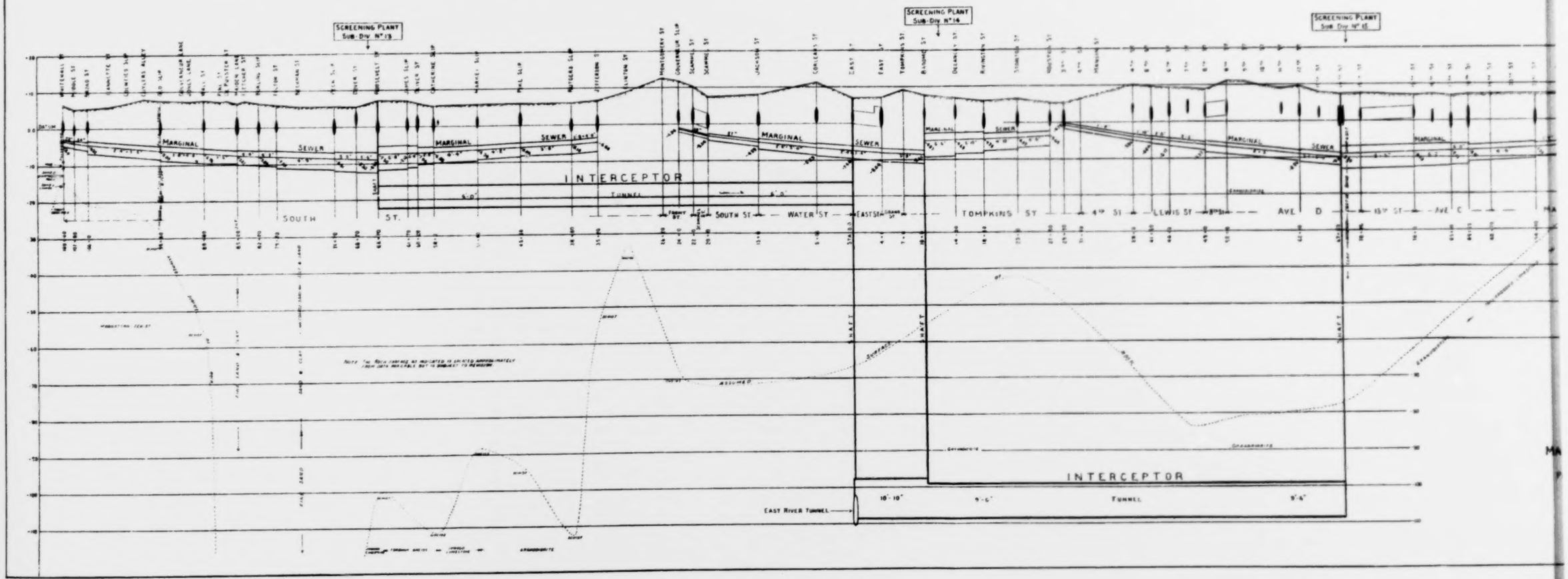
(Here follow plates marked I, II, III, IV, and V, Exhibit No. 202.)

(Exhibit No. 202)

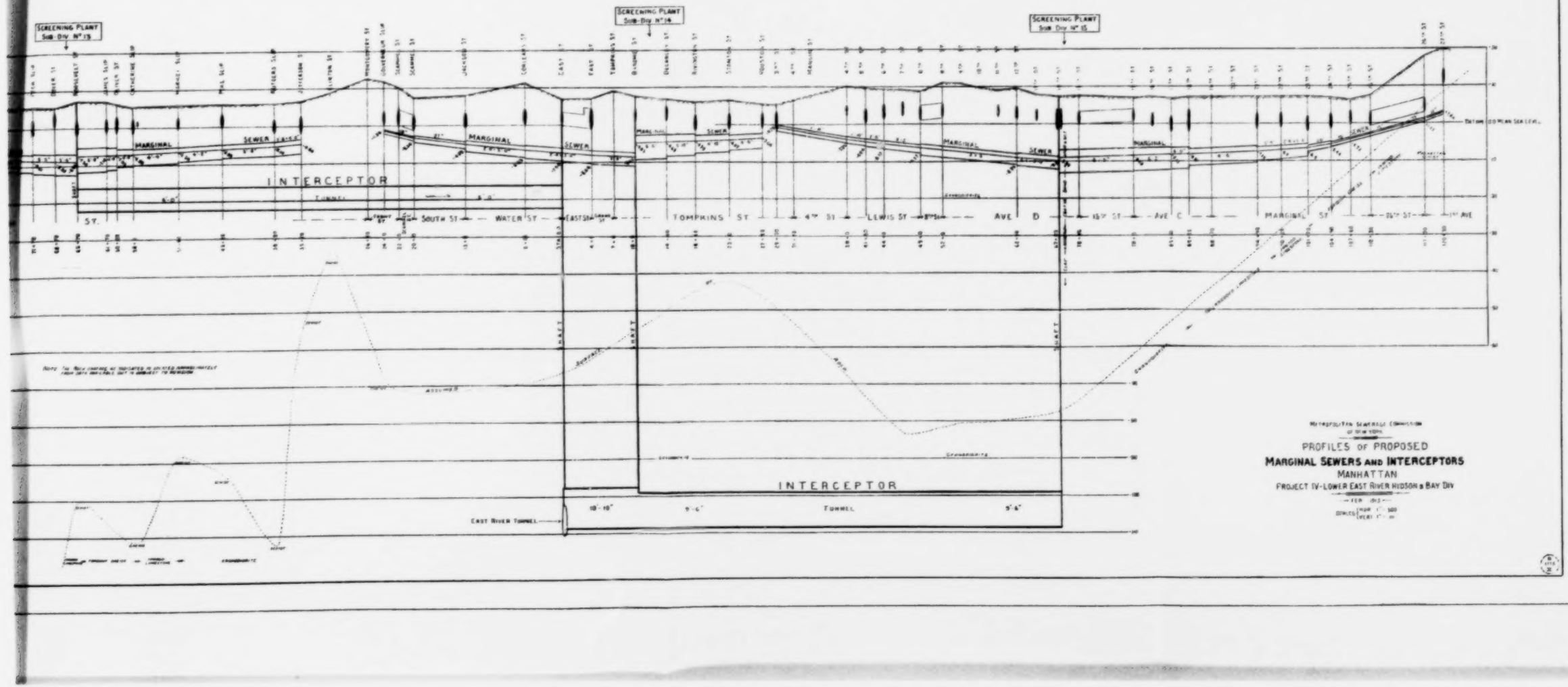
PLATE I

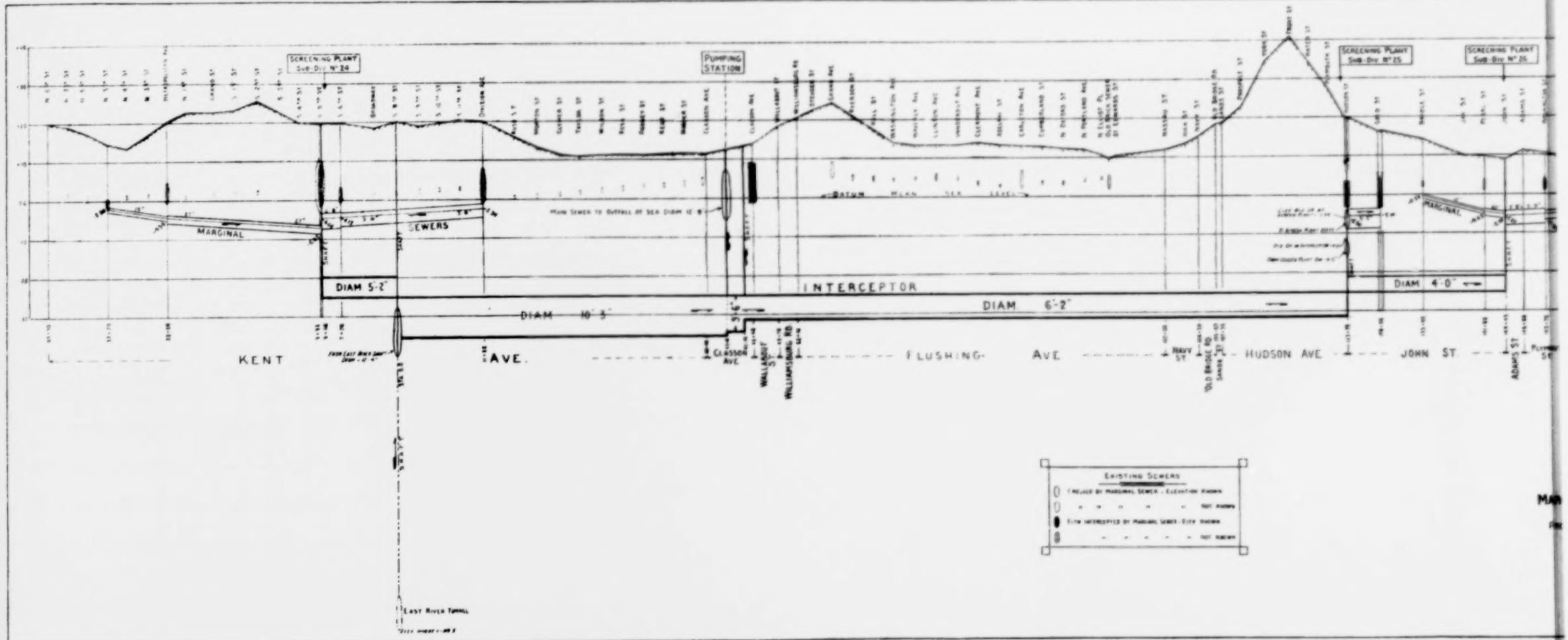


PROJECT FOR THE RELIEF OF THE LOWER EAST RIVER
AGAINST EXCESSIVE POLLUTION

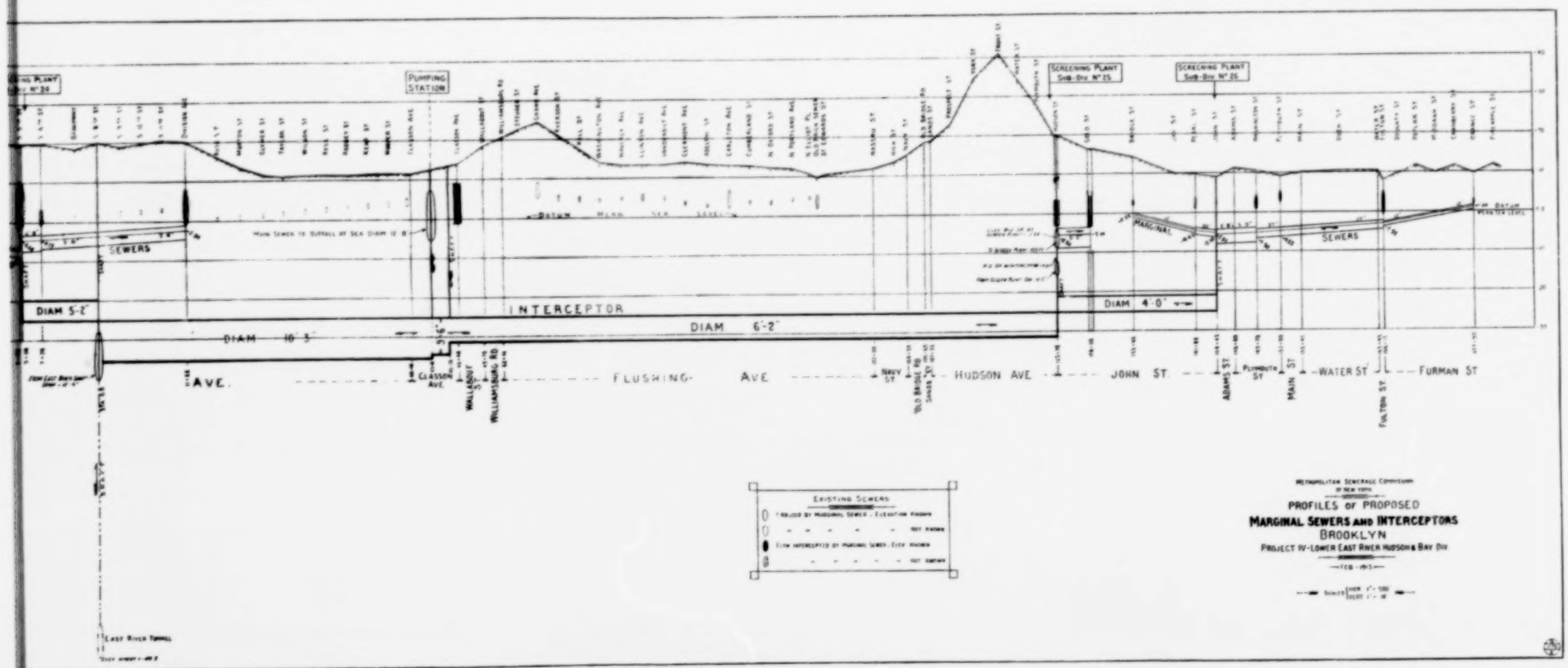

SCREENING PLANT
SUB-DIV N°13
SCREENING PLANT
SUB-DIV N°14
SCREENING PLANT
SUB-DIV N°15
MARGINAL
SEWER
INTERCEPTOR
TUNNEL
SOUTH ST.
SOUTH ST
WATER ST
EAST ST
TOMPKINS ST
4TH ST
LEWIS ST
AVE D
15TH ST
AVE C
SHAFT
EAST RIVER TUNNEL
10'-10"
9'-6"
TUNNEL
9'-6"
INTERCEPTOR

(Exhibit No 202)
PLATE II




SCREENING PLANT
Sub-Div N° 24
PUMPING STATION
SCREENING PLANT
Sub-Div N° 25
SCREENING PLANT
Sub-Div N° 26
MARGINAL
SEWERS
DIAM 5-2"
DIAM 10'-5"
INTERCEPTOR
DIAM 6'-2"
DIAM 4'-0"
MARGINAL
DATUM MEAN SEA LEVEL
KENT AVE.
CLASSON AVE.
WALLABOUT ST.
WILLIAMSBURG RD.
FLUSHING AVE
NAVY ST.
OLD BRIDGE RD.
HUDSON AVE.
JOHN ST.
ADAMS ST.
EAST RIVER TUNNEL
EXISTING SEWERS

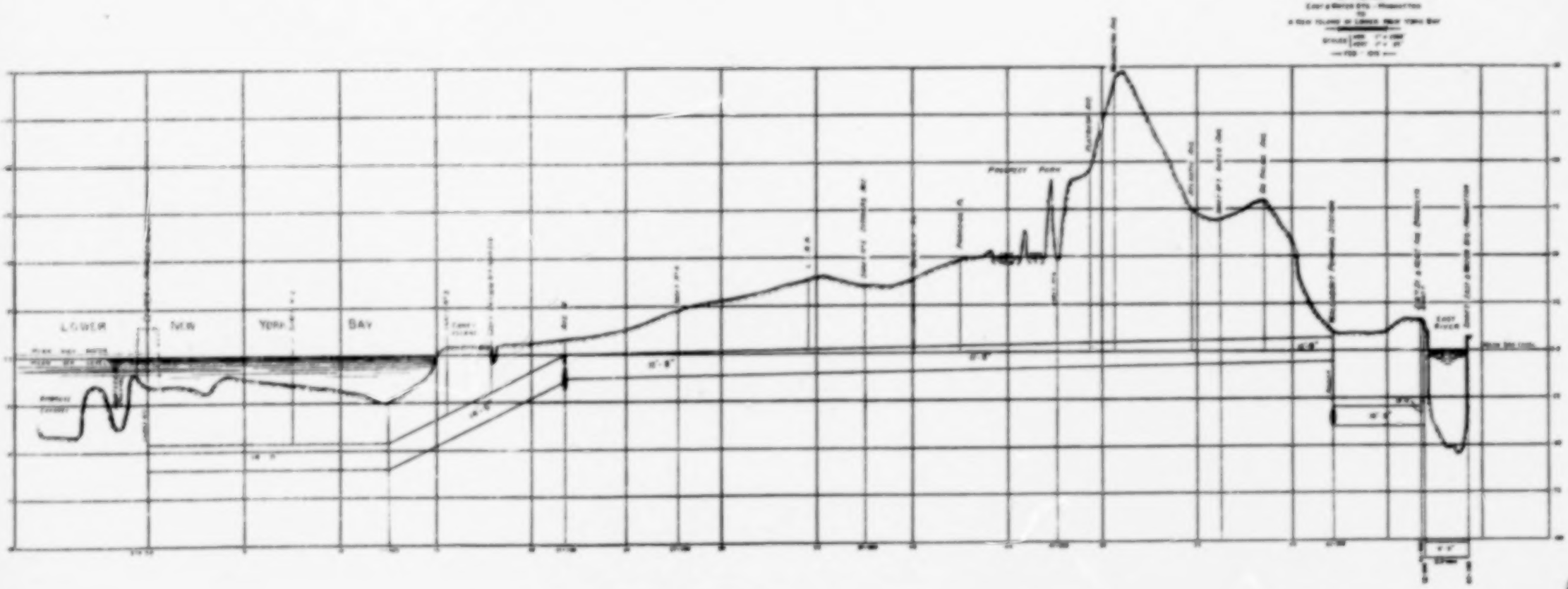
(Exhibit No 202) PLATE III



(Exhibit No. 202) PLATE IV

PROJECT IV

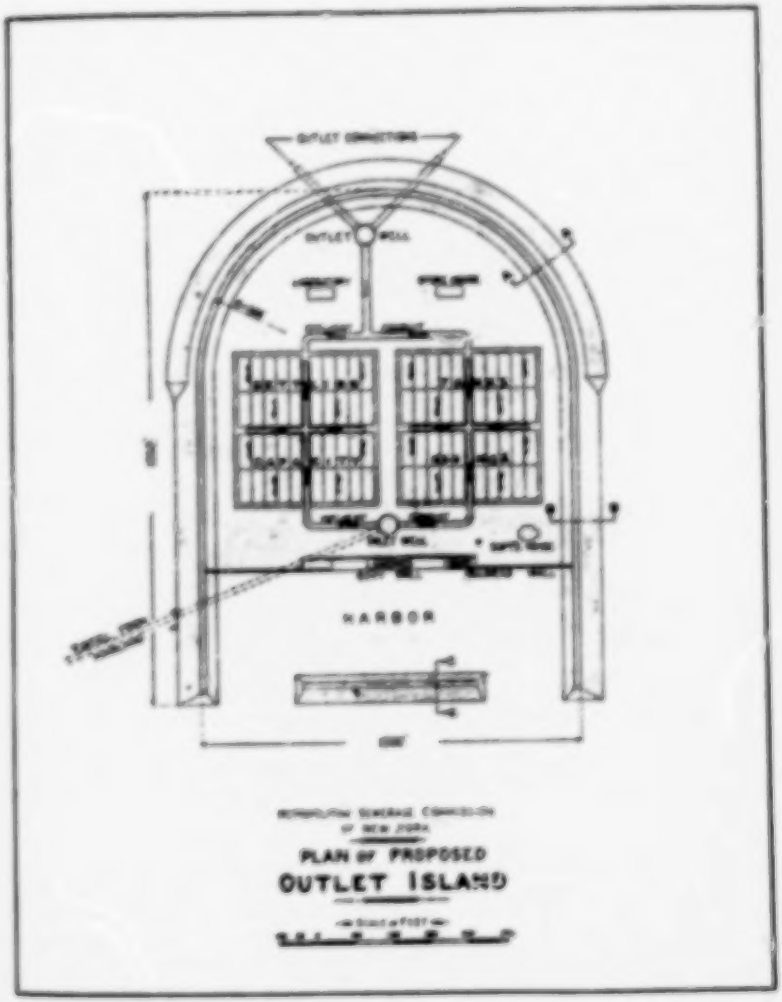
PROFILE OF OUTFALL TUNNEL



48° Ec 202

(Exhibit No 202)

PLATE V



METROPOLITAN SEWERAGE COMMISSION
OF NEW YORK

PLAN OF PROPOSED
OUTLET ISLAND

49 *Appendices.*

I.

Studies for Grit Chambers, Screens, and Regulators.

The grit and screen chambers could be constructed, beneath the level of the street pavements, but in all cases it would be desirable, and in some instances probably necessary, to provide a super-structure. All the plants would be small and where a building over them was necessary, it could be made architecturally unobtrusive in appearance. If the sewage were collected by a combined system of sewage, the plant would require to be provided with means for separating a part of the storm water and the latter could discharge directly to the water. It would be feasible to pass three times the dry weather flow of sewage through the plant during periods of storm, and if this were done the work of the water from the streets would be provided for in the works. A study for a grit chamber is shown in Plate VI, following page 52.

In addition to the provisions for avoiding an excess of storm water, the principal features of the plants would be a grit chamber and screens, pumps, tide gates and submerged outfalls. The grit chamber would be essentially an enlargement of the sewer and be of such design as to provide for the slowing of the sewage flow as much as practicable. A prominent feature should be the means for cleaning out the grit and other solid matters which would be deposited. Elaborate methods for cleaning grit chambers are employed in some European sewage disposal works, but simple and effective dredging apparatus appears to be preferable. The material dredged from the grit chamber should be dumped into suitable carriers. These carriers, which could also carry away the screenings would operate electrically. They should convey the materials to some dock or pier where a vessel could carry the impurities to sea or the inflammable part of the refuse could be disposed of by burning.

On passing from the grit chamber the sewage should be screened. After considering many types of screens employed in Europe and America, including those capable of removing the utmost quantity of suspended matter possible, it seems best to employ a moving bar screen with openings of about 4/10 of an inch. The type used in the new installation at Hamburg, Germany, appears to be suitable for New York. This screen consists of an endless belt of bars arranged at an inclination to the flow of the sewage. The sewage passes between the bars and leaves the solids, which are caught and carried upward on the screen belt as it slowly revolves. The screens which are carried up out of the sewage are removed from the belt by means of brushes and a hose and discharged upon a belt conveyor
50 which carries the material to a car which stands in readiness.

The size of the openings between the bars of this screen do not necessarily indicate the size of the particles removed from the sewage. If the screen is revolved very slowly, its effectivness in re-

moving suspended matter will be increased. After the sewage leaves the screens, it passes to the pumps. The pumps should be of the centrifugal type directly connected to motors. The pumping equipment should be in duplicate, as should the screens and grit chambers.

Leaving the plant, the sewage should flow under slight pressure to the outer ends of piers, where it would pass downward through a pipe to the bottom and thence outward into the current for discharge. The tide gates should be located near the point where the sewage is passed through the grit chambers and screens.

In order to consider the practicability of installing grit chambers and screens, locations have been tentatively chosen for the outlets and the approximate locations of the works fixed. The next step was to separate the division into subdivisions and select a few of those for more detailed study. The collecting system in each subdivision was assumed to be already complete save for such interceptors and other large sewers as might be needed to gather the sewage which was now passing to the harbor through many outlets to the central plants. Four sub-divisions were selected for special study, in which the topography and other conditions were dissimilar.

Sub-division No. 5.—One of the sub-divisions was on the Hudson river shore of Manhattan Island, between the northern end of Central Park and the Riverside Park. The sewage from this area is produced by a high-class apartment house population. The topography is such that no difficulties to drainage exist. The site for the plant was in Riverside Park at 96th Street. The quantity of sewage was 25.4 million gallons per 24 hours during dry weather and three times this quantity was provided for at the plant. The storm water outlets were intended to be carried to the end of the West 97th Street pier and were given a capacity of 270 million gallons per day. The cost, including excavation, sub-structure, super-structure and 15% for contingencies, was $89,000 for the plant. The outlets for the dry weather flow would run to a point 300 feet off the pierhead and would cost about $24,200. The outlets for the storm water overflow at the pierhead would cost about $37,000. Total, $150,200. This estimate does not include the cost of intercepting the sewage and delivering it to the treatment plant.

Sub-division No. 14.—The second sub-division studied would have a treatment plant at Broome Slip, near the East river. In this case the area drained is occupied by a crowded tenement house
51 population. There would be difficulty in collecting the sewage to the plant, since the ground is, for the most part, low. The works would have a total capacity of 93 million gallons, which would be about three times the dry weather flow. Storm water in excess of this quantity would be diverted directly to the East river, and the rest raised by pumping. In all other essentials the plant would be similar to that at 96th Street. The estimated cost, including excavation, sub-structure, super-structure, machinery and 15% for contingencies, is $133,000. This figure does not include the cost of collecting the sewage and delivering it to the plant or of conveying it from the works to the outlets.

Sub-division No. 19.—A third sub-division studied contemplates the location of a plant at Orchard Street, Astoria. In this case the capacity would be 87 million gallons per day or three times the dry weather flow. Difficulties of drainage due to low-lying land would require pumps to lift the low level sewage to the works. The estimated cost for excavation, sub-structure, super-structure, machinery and contingencies would be $81,700, exclusive of the cost of delivering the sewage to the plant or conveying it thence to the outlet.

Sub-division No. 30.—A fourth location for a grit chamber and screening plant would be at the foot of 64th Street, Brooklyn. The capacity in this case would be 68 million gallons per day or three times the dry weather flow. The cost, including excavation, sub-structure, super-structure, machinery, connection with sewer and 15% for contingencies, would be $147,000, exclusive of cost of conveying the sewage from the plant to the outlet.

If there was one grit-chamber-and-screening plant, in each sub-division, the total number would be thirty-one. If their cost is indicated by the studies made for the four sub-divisions mentioned, the total outlay for them would be in the neighborhood of $710,000. This would exclude land and the outfalls.

Heavy Rainfalls.—Inasmuch as the frequency with which the storm overflows would come into play should be considered, studies have been made of the records of precipitation as kept by the United States Weather Bureau. The maximum precipitation in each month for 5, 10 and 60 minute periods from April 1, 1896 to January 1, 1912, and for 15, 30 and 120 minute periods from January 1, 1903, to January 1, 1912, have been examined. The results for the months of December, 1895, January, 1897, and February, 1898, are missing. The tabulations of the Weather Bureau were for the most severe single storm each month and it is possible that the actual frequency would slightly exceed that indicated by these diagrams. But the difference would not be so great as to be of consequence in any provision for storm water overflows.

On applying the results of these studies of rainfall, it appears that a volume of storm water in excess of three times the dry
52 weather flow would occur on an average once in about 3½ months and six times the dry weather flow would be received about once in ten months. Ten times the dry weather flow would happen about once in three and one-half years, and the maximum flow for which the plant would be designed, above which the sewer would be surcharged, would occur about once in 6½ years.

Annual Costs.—The annual costs of operating the grit chamber and screening plants have been approximately estimated. These charges do not include fixed charges required on account of intercepting the dry-weather flow nor do they cover the provision of storm water overflows or submerged outlets. The solid matter removed by the basins and screens would be carried, according to these estimates, to the nearest public dump: from the two Manhattan plants by motor trucks serving about four plants each; from the Astoria plant, by chutes to a steamer; from the 64th Street, Brooklyn, plant, it would be conveyed for a short distance to the water

front. In each case, it would be taken to sea by a steamer for disposal. Still better, the screenings could be burned.

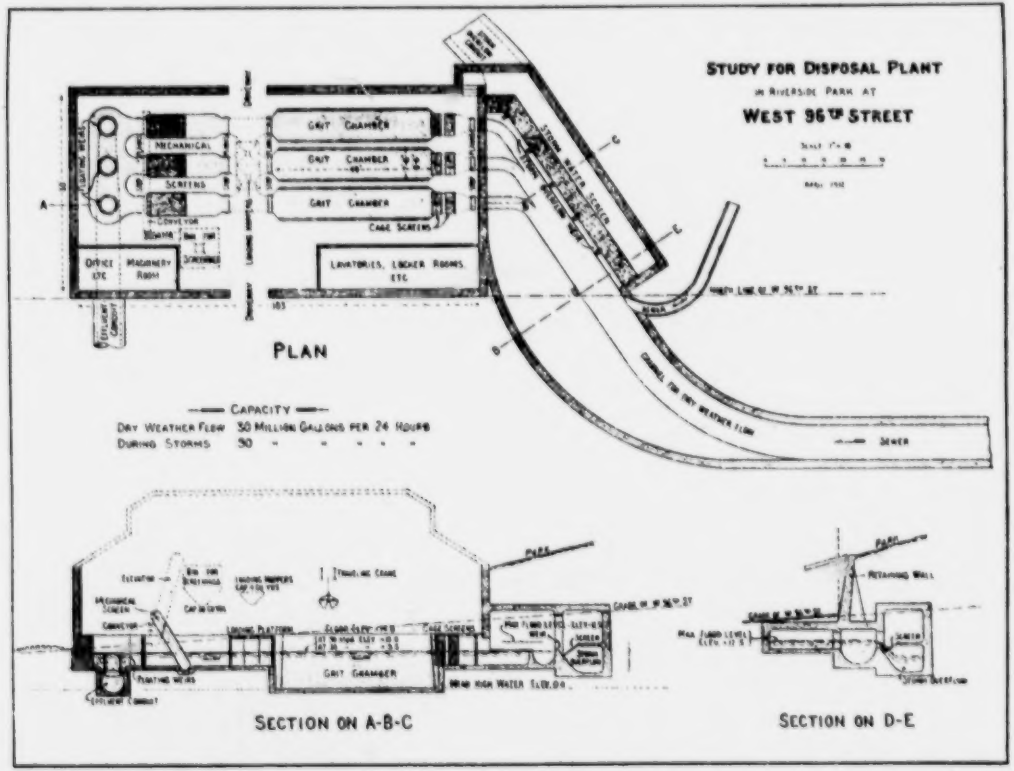
The amount of sludge produced has been assumed to be one ton per million gallons of sewage. These estimates are based on the assumption that a sufficient number of plants are in operation to warrant the use of a sludge steamer without which the sea discharges per ton would be much greater than the amount here indicated.

Estimates of Annual Expense of Grit Chamber and Screening Plants.

	W. 96th St., Manhattan.	Broome Slip, Manhattan.	Orchard St., Astoria.	64th St., Brooklyn.
Dry-weather flow, million gallons per day	30	33	30	50
Operation	$6,600	$8,100	$7,380	$8,100
Salaries	2,640	29,000*	9,420†	3,100
Power, light and supplies	9,300	37,100	16,800	11,200
Fixed Charges	4,500	6,730	4,134	7,438
Total	$13,800	$43,830	$20,934	$18,638
Per Mgd	460	1,328	698	373
Sludge Disposal	1,825	1,848	547	1 825
Land charges	1,645	1,807	1,643	2,737
Sea charges	$3,470	$3,655	$2,190	$4,562
Per Mgd	116	111	73	91
Grand Total	$17,270	$47,485	$23,124	$23,200
Per Mgd	576	1,439	771	464

* Including pumping.
† Pumping 8.9 million gallons per 24 hours.

(Here follows Plate VI, Exhibit No. 202.)



(Exhibit No. 20)

PLATE VI

53

II.

Studies for Tide Gates.

Most of the grit chambers and screens would be situated so close to the tidal level that the plants would be in danger of flooding through the outlet pipes if provision was not made to prevent it. To prevent flooding, tide gates would be needed and these should be of the most reliable form procurable.

Many forms of tide gates have been considered by the Commission, the experience of engineers in America and England being taken carefully into account, and special attention being paid to the best current practice in this direction in Holland. As a result, it is believed that although tide gates are not always reliable, a form can be designed which will satisfactorily answer the requirements of the situation.

Tide gates in common use are of three general types: flap valves, swinging gates and sluice gates.

Flap Valves.—Flap valves which swing on a horizontal hinge are most often used on sewer outlets of moderate or small size, although good examples of this type exist in some large sewers. At Washington, D. C., gates are used which are made of Georgia pine 5 feet 6 inches wide by 8 feet high and at Philadelphia there are gates of yellow pine 18 feet wide and 2 feet high. With large sizes, two flap valves are usually placed in the gate, one above the other, as at Aberdeen, Scotland, and Atlantic City. At Aberdeen, the balanced flaps are of cast iron and the opening for discharge is 5 feet 6 inches by 6 feet 6 inches.

For the flaps to work freely, they should hang loosely from links, as at Atlantic City, or from easy-working hinges. Composition bearings are desirable in order to avoid corrosion. At Washington the hinges and bolts are of bronze. A ring of rubber set into the gate forms a watertight joint, with a cement seat. At Philadelphia, a rubber gasket is provided which bears against a copper seat. To aid in securing a tight closing of the valve, the seat is usually inclined to the vertical; 1 in 6 at Washington, and 30° at Philadelphia.

If the sewer is of large size, the weight of the flap gate may be so great as to interfere with the free discharge of the sewage. Gates which swing on a vertical axis have an advantage over flap valves in this respect. The leaves of such gates are usually made of wood, white pine being used in some cases, as in Boston. To insure tight closing, a counterweight may be hung on a chain passing from a rod projecting from the outer end of the gate to a point above the hinges. In a patented device used in Boston, the hinges are slightly inclined so as to offset in part the buoyancy of the gates which tends

54 to keep them open. To further insure tightness in the Boston gates, a lead weight which is moved by gravity in a closed sheath attached to one leaf of the gate is hung on a chain which passes over a pulley and then horizontally to a post on the other leaf. The counterweight is thus kept out of the sewage. A rubber strip is attached to the bevel end of one leaf and to each leaf is at-

tached a rubber strip opposite the seat to insure tight closing. A study for a flap tide gate is shown in Plate VII, following page 54.

Sluice Gates.—Sluice gates, or penstock gates as they are often called in Europe, are sometimes employed to more certainly secure protection from back water. In some instances, as at Kings Lynn, a sluice gate is placed behind a flap valve for the added security which is thus afforded. Sluice gates for this use are generally of cast iron and are raised by a screw. As the weight is considerable, a counter-weight is often provided, as in the case of a flushing gate in Boston. If the gate is double, it will facilitate opening, the lower half being raised first. An added advantage in having double gates lies in the saving which they afford in head room in case the lower gate is of large size.

Large sluice gates should be mechanically operated, as at Portsmouth, where turbines actuated by the sewage are used to operate twelve 3 foot by 3 foot 9 inch gates. Auxiliary inlets to the turbines are there first opened by hand, although it would seem possible that the operation could be entirely automatic.

At Aberdeen there are two penstock gates, one closing against the tide and one against the sewage, with a flap valve between. They are about 6 feet 6 inches square, with gun metal facings. Each is operated by a 30-inch hydraulic cylinder using water pressure of 35 pounds per square inch.

If properly designed and regularly inspected, flap valves are an efficient means of excluding tide water from sewers, but there is always some chance that wood and other floating substances may become caught in the opening and prevent the flap from closing tightly. The Washington gates afford an excellent example of the reliability and economy of this type of tide gate. Sixteen of these gates have now been in service seven years without any expenditure for repairs.

For very large sewers, swinging gates are to be preferred to any other means of excluding tide water. Sluice gates are more certain than flap valves and swinging gates to close tightly, but they are costly and cumbersome, both to construct and operate. Where the tidal ranges are great, they have advantages over other forms on account of their strength and compactness. In all cases tide gates should be built in duplicate.

(Here follows Plate VII, Exhibit No. 202.)

(Exhibit No 202)

PLATE VII

55

III.

Studies for Submerged Outfalls.

The value of submerged outfalls lies in the fact that they materially aid in bringing about a prompt and thorough mixture of the sewage and water into which the sewage is discharged.

Preliminary to describing a form of construction which appears to be practicable for submerged outlets in the sub-division with which this report deals, it is desirable to consider the circumstances under which sewage will and will not mingle with the surrounding water.

Dispersion and Diffusion.—The terms dispersion and diffusion are sometimes used interchangeably in describing the intermixture of sewage and water, although, strictly, there is a difference in their meaning. The term dispersion implies a separation and scattering, particularly of solid particles, while diffusion refers especially to that form of rapid and intimate mixture which is most often considered as taking place among gases. Both dispersion and diffusion are necessary for the disappearance of sewage. The solids must become scattered and the liquids must become diffused. When solids accumulate, they may form deposits or else masses which are visible at the surface. Unless the liquids become diffused, they do not come into contact with the oxygen which is necessary for their mineralization. When dispersion and diffusion are satisfactory, the discharge of sewage into a large body of water is scarcely, if at all, detectable to the sight.

It is sometimes erroneously assumed that diffusion is everywhere and at all times proceeding rapidly among the liquid particles naturally present in large bodies of water, particularly in such bodies as move under tidal influences, and that to cause sewage to be carried away, it is only necessary to discharge it in not too great quantity. This is a mistake. Some bodies of water should never receive any sewage.

A prompt and general intermixture of sewage and water is often difficult or impossible to accomplish. It is most difficult when the water into which it is emptied has no current or when the current is so slow that there are no eddies or counter currents produced. The eddies and counter currents are necessary for rapid diffusion. It is not enough that the water into which the sewage is discharged should be great in volume, nor that the water should be flowing by a point of discharge at a great velocity. If the velocity is uniform throughout, dispersion and diffusion will not be as satisfactory as it would be if cross currents and eddies existed in it.

56 Ascent of Sewage in Sea Water.—Diffusion between sewage and sea water is more difficult than between sewage and land water by reason of the greater specific gravity of sea water. Each cubic foot of sewage is 1¾ pounds lighter than an equal volume of sea water and, in consequence of this fact, every foot which is discharged beneath the surface may be considered to be urged upward

with a force of about 1¾ pounds. This upward force diminishes as the sewage becomes mixed with the water and is initially less if the harbor water is not as salt as the sea. From the mathematical equation $V^2=2gh$, it is evident that the rate of ascent will vary as the square of the difference in specific gravity, and that the velocity of ascent will be doubled when the buoying force is multiplied four times.

It is, unfortunately, impossible accurately to determine the velocity of ascent of a stream of sewage by means of this or any other formula, but the facts stated are of practical use in considering the best means of causing a prompt and intimate mixture of the sewage and tidal water to take place.

Many experiments have been made by the Metropolitan Sewerage Commission to obtain information concerning the circumstances under which sewage could and could not be made to diffuse in the water of New York harbor. These experiments were carried on in the laboratory, in large aquarium tanks and in the harbor itself. In the latter case, hogsheads and tank steamers loaded with sewage were taken to various parts of the harbor and, after being strongly colored with dye, discharged beneath the surface, and the resulting phenomena noted. In these experiments the harbor water varied in salinity. It usually contained about 75 per cent. of sea water. The current into which the sewage was discharged varied from a little less than 1 foot per second to 3 feet per second. Most of the large scale experiments were carried on near the center of Upper New York bay. Further details of this work are described in the report of the Commission of April, 1910, pages 184-215, but the following facts and opinions derived from these studies are of interest here. When sewage is discharged into sea water, the sewage will rise to the top in a mass unless it is intermixed through the mechanical action of eddies and cross currents. Tending to carry the sewage to the top are gas, grease and light solid particles. The sewage is usually warmer than the water into which it is discharged and this difference in temperature tends to carry the sewage upward.

When sewage is discharged into a mixture of 85 per cent. of land water and 15 per cent. of sea water, it appears to be practically in equilibrium, that is, it neither rises nor falls through the water into which it is discharged.

When sewage is allowed to stand at the top of a perfectly
57 quiet body of water, diffusion occurs at once if the water is land water, but not until 48 hours, if the water is a mixture of equal parts of land water and sea water. When sewage is discharged beneath the surface of a quiet body of water, currents are set up which help to produce an intermixture between the two fluids. The force of these currents varies directly with the velocity of the discharging current and the volume of discharge, and is helpful in bringing about dispersion and diffusion. When sewage is discharged beneath the surface of a quiet body of water of practically the same specific gravity, it does not intermingle immediately with the surrounding water. Some diffusion takes place from the outside edges

of the discharging stream, but intermixture seems to proceed chiefly after the discharging stream has lost its initial velocity. It is obvious from these facts that the velocity is an important factor in the mixing process.

If directed vertically upward from a submerged outfall, a discharging stream of sewage flows toward the surface of the water in a gradually enlarging column. Arrived at the top, the sewage spreads out thinly over the surface. Diffusion gradually takes place downward from this surface. If discharged horizontally from a submerged outfall, the sewage stream at first preserves its integrity for a considerable distance and then, rising upward, spreads out in a thin layer at the top of the water. Diffusion takes place in this case downward from the gradually enlarged column and from the surface layer, as when sewage is directed vertically upward from a submerged outfall.

When sewage is discharged into a quiet body of tidal water consisting of 40 per cent. land water and 60 per cent. sea water, it rises toward the surface irrespective of the direction of the discharge from the orifice, and spreads out upon the surface in a thin layer. The upward motion is not retarded perceptibly when the discharge takes place at a velocity of 1½ feet per second into quiet water.

The shape of the discharging column of sewage is larger and longer when the discharge takes place in a horizontal direction than when the discharge is upward or downward, and for this reason, a horizontal discharge facilitates diffusion. To secure the most prompt and thorough intermixture, the sewage should be discharged in a horizontal direction near the middle and at the bottom of a tidal channel and in a direction perpendicular to the direction of flow of the current.

Three conditions are desirable in order to accomplish satisfactory diffusion:

1. The diameter of the discharging column of sewage should be small.

2. The velocity of the discharging column of sewage should be great.

3. The current into which the sewage is discharged should be rapid.

58 Investigations in Boston Harbor.—The water in the vicinity of the Boston, Mass., outlets was analyzed by the Metropolitan Sewerage Commission of New York during the month ending September 18, 1911. The analyses were intended to show the amount of dissolved oxygen in the water, the salinity and temperature being determined at the same time. The examinations covered the inner and outer harbor and there were special studies made of the three main outlets. The total number of analyses was 388. The method employed, the analyst and the floating laboratory were the same as had produced the large amount of information concerning the oxygen in the waters of New York harbor.

The condition of Boston's inner harbor, as measured by the dissolved oxygen was, in the main, very satisfactory, although there

were some places where the circulation of tidal water was insufficient to carry away the sewage which was discharged. The outer harbor, except in the immediate vicinity of the three main sewer outlets, contained an abundance of dissolved oxygen.

The conditions surrounding the Peddocks Island outfall were better than those found at Deer Island or Moon Island. It became apparent that the sewage began to be dispersed and diffused from the moment it left the outfall at Peddocks Island. The shape of the ascending column of sewage was somewhat like a funnel with incurved sides and broad flare. At a distance of 500 feet from the center, there was 7 per cent. of sea water mixed with the sewage at the surface. There was 3 per cent. 10 feet below the surface and 1 per cent. 15 feet below the surface. At 1,000 feet from the center there was no sewage below 10 feet beneath the surface. At 2,000 feet there was no sewage below 2 feet beneath the surface.

The amount of oxygen present varied with the concentration of sewage. At a distance between about 700 feet and 1,700 feet from the center of the sewage field, there was a considerable increase in the exhaustion of oxygen.

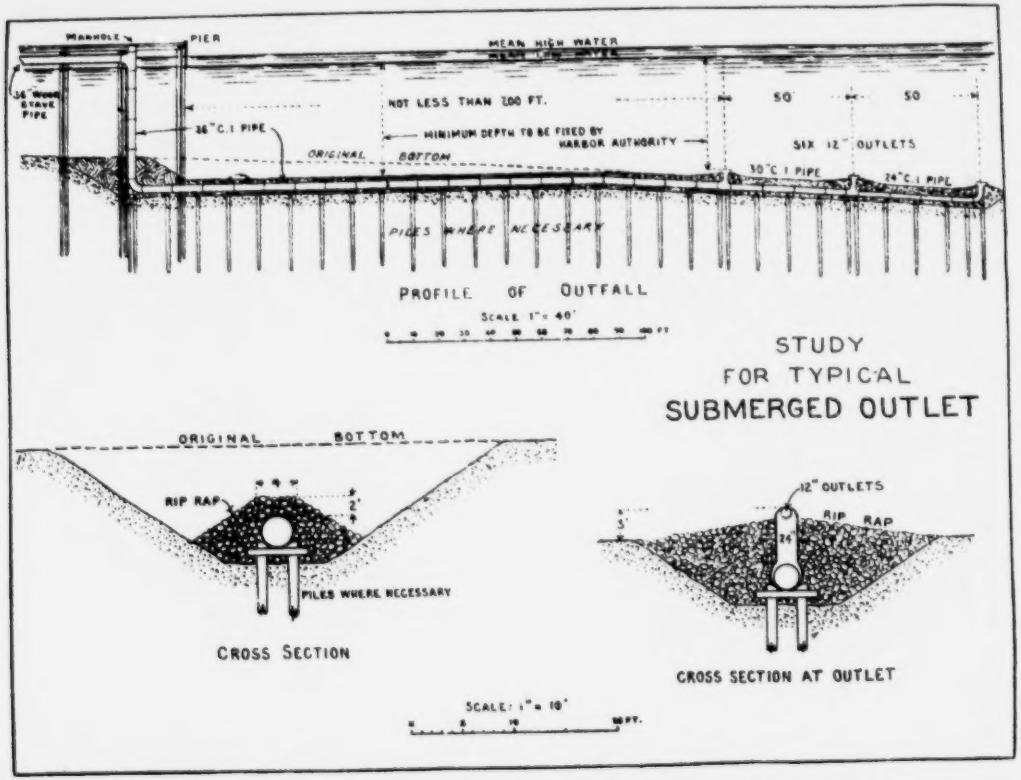
Submerged Outlets for Manhattan and Brooklyn.—For the discharge of sewage from Manhattan and Brooklyn it is desirable that submerged outfalls should generally be employed. In some cases they should extend sufficiently far from the outer ends of the piers to obtain the advantages of great depth of water, high velocity of tidal current and remoteness from observation.

The types of construction suitable for carrying the sewage to the bottom of the main tidal channels must differ according to local circumstances, particularly the depth of water and character of the bottom, whether of silt or mud or rock. In the Lower East river the currents are so swift and the bottom so hard and the traffic so great that submerged outfalls can be constructed only with difficulty. On the Hudson river side of Manhattan Island, the
59 & 60 conditions are more favorable and for this area a type of outfall has been designed.

The capacity of the type of outfall which is here outlined for the Hudson river side of Manhattan Island can be increased beyond that mentioned, although the sizes given will be found economical to construct and it may be undesirable to collect more sewage to a single point for disposal than can be discharged through one outfall of this type.

The plan is to carry the sewage through a 36 inch wood stave pipe laid beneath a pier to a point near its outer extremity. The wood stave pipe would be joined at its outer end by a 36 inch cast iron pipe which would be placed vertically and extend to the bottom of the water. At the top a manhole would be provided for easy access for inspection, cleaning and repairs.

At the bottom of this vertical leg the 36 inch cast iron pipe would turn and run out into the tidal channel for a distance of not less than 200 feet from the outer end of the pier. At this distance there would be a short riser of 24 inch pipe, provided with two 12 inch



(Exhibit No 20 2)

PLATE VIII

outlets which would discharge in a direction parallel to the main line of the pipe and perpendicular to the direction of the tidal currents.

From the riser just mentioned, the cast iron pipe, now reduced to 30 inches, would extend 50 feet further from shore to a second riser similar to the first. From this point the cast iron pipe reduced to 24 inches in diameter would extend the final 50 feet to its outer limit, where it would be joined by a third riser to discharge the remaining sewage, as in the first two cases.

The cast iron pipe would, where practicable, be laid in a trench dredged in the bottom. Where the support was poor or uncertain, piles would be driven to carry the pipe. The pipe would be covered with a light filling of rip-rap and the trench filled. The minimum depth at which outfalls of this character should be constructed would have to be fixed by the Harbor Line Board. Apparently there is a depth of water in the Hudson river along the Manhattan shore at practically all points sufficient to permit this form of construction to be adopted. A study for a submerged outfall is shown in Plate VIII, following page 60.

The submerged outfalls would be for the dry weather flow of sewage. Storm water would be overflowed under the piers. The dry weather flow of sewage would generally be carried to the submerged outfalls by pumping.

(Here follows Plate VIII, Exhibit No. 202.)

61

IV.

Opinion of U. S. Engineers on the Proposed Island.

Recognizing that responsibility for the maintenance of a proper depth of water for navigation in the harbor rested with the U. S. War Department and that the island proposed by the commission for the disposal of the sewage of the Lower East river could be constructed only with the permission of that Department, application was made to the Secretary of War requesting the views of the War Department with respect to this subject. The commission's application was referred by the Secretary of War to the Chief of Engineers, U. S. Army, and by him to the New York Harbor Line Board for report.

The New York Harbor Line Board consists of Colonels W. T. Rossell, W. M. Black and S. W. Roessler of the Corps of Engineers, U. S. Army. The island would be in that part of the harbor which is under the special jurisdiction of Col. Roessler, who has had much experience with breakwaters and other structures intended to resist the destructive action of the sea. The Harbor Line Board gave a hearing on the commission's project on March 7, 1913. On that occasion the subject was thoroughly discussed, plans, charts and profiles of the proposed structures being produced.

The opinion of the Harbor Line Board was transmitted to the commission by the War Department on March 22, 1913. It was to the effect that an island in either of the two locations suggested by the commission, one of which is shown on Plate I, following page 48 of Preliminary Report VI of the Metropolitan Sewerage Commission, would not interfere unduly with navigation nor have an unfavorable effect upon the harbor. In this opinion the Chief of Engineers concurred.

The correspondence in full follows:

February 18, 1913.

Hon. Henry L. Stimson, Secretary of War, Washington, D. C.

SIR: In making plans for a sanitary disposal of the sewage of New York City, it has become desirable to consider the practicability of constructing an island near the entrance of New York harbor. The island would be located on one of the shallow, sandy bars which are divided by the Fourteen Foot Channel to the north of Ambrose Channel.

62 The island would be constructed with an enclosing wall of rip-rap and a filling of sand or other solid material, the total area occupied being less than 30 acres. Upon the island would be tanks and other structures in which much of the solid matters of the sewage would be removed to be carried to sea in boats or disposed of in some other acceptable manner, while the clarified effluent would be discharged into the surrounding water through outlets so arranged as to insure its prompt dispersion and disappearance. The sewage, amounting to about 200,000,000 gallons per twenty-four hours, would be brought to the island through a tunnel.

Recognizing the authority which is exercised by the general gov-

ernment over the navigable waters, this commission desires to place its project in sufficient detail before you, to the end that an early determination may be reached as to the permissibility of constructing and using this island in the manner, and for the purpose, stated.

Members of this commission will be pleased to call upon you with reference to the subject in case you visit New York, or they will go to Washington to see you, if preferable. The technical details of this plan can be laid before such army engineer, officer or officers of the New York Harbor Line Board as you may designate.

Your early attention to this subject is requested in order that the result of your consideration may be known in time to be used in a report soon to be issued by this commission.

Respectfully,

GEORGE A. SOPER,
JAMES H. FUERTES,
H. DE B. PARSONS,
CHARLES SOOYSMITH,
LINSLY R. WILLIAMS,
Commissioners.

March 3, 1913.

Mr. George A. Soper, President, Metropolitan Sewerage Commission, 17 Battery Place, New York City.

DEAR SIR: 1. The Harbor Line Board has before it your application of Feb. 18 to the Secretary of War concerning the construction of an artificial island near the entrance to New York harbor, and also a letter of Feb. 19th from Mr. H. de B. Parsons, Consulting Engineer, requesting that this matter be laid before this Board. In order that the Board may be able to come to a [illegible] conclusion in the case, it is requested that you submit more detailed plans and make a definite application for such construction.

63 2. The Board desires to take this matter up at 10 a. m. on March 7th and it is requested that these plans be submitted before this time and that if possible you or your representatives be present to confer with the Board in the matter on that date.

Very respectfully, WILLIAM T. ROSSELL,
Colonel, Corps of Engineers, Senior Member of Board.

March 6, 1913.

Colonel William T. Rossell, Corps of Engineers, New York Harbor Line Board, Army Building, New York City.

DEAR SIR: Your letter of March 3, relating to the proposal of this commission to construct an island near the mouth of New York harbor, has been received.

Application is hereby made for permission to construct and maintain an island for the treatment and disposal of sewage in accordance with the following plan:

The object of constructing the island is to afford opportunity for the treatment and final disposition of a quantity of sewage from the inner harbor sufficient to relieve and protect the inner harbor from its excessive burden of pollution.

The location proposed for the island is in shoal water, preferably

in latitude 40° 32′ 02″ N, longitude 73° 59′ 46″ W, or in latitude 40° 31′ 26″ N, longitude 73° 58′ 21″ W.

In plan, the island would be approximately rectangular except that the seaward side would be rounded. The area at the start would be about 20 acres of filled land and about 10 acres of harbor for the protection of vessels engaged in transporting supplies to the island and taking sludge and other materials away.

The outer face of the island will be a wall of rip-rap composed of large pieces of broken stone carried to the site on boats and laid upon the hard sandy bottom. It is expected that some settlement will at first occur, due to the water cutting sand away from under the stone. The main bulk of the island will be composed of sand supplied from a suction dredge which will take its supply from the bottom of the sea, or earth, ashes and other suitable material.

The height of the island above mean low water will be about 18 feet. The length of the island, when first constructed will be about 1,300 feet and the width 1,000 feet. The side of the rip-rap wall which is exposed to the sea will have a slope of 1 vertical upon 3 horizontal and the two adjoining sides will have an outer slope of about 1 on 2. The rip-rap will be 15 feet across the top and
64 will be surmounted by a concrete parapet wall 4 feet in height. The rip-rap will be from 75 to 122 feet wide on the bottom, according to the location with respect to the sea.

The island will contain a plant of settling tanks in which the sewage will have an opportunity to settle and deposit its solid matters during a period of about two hours. These tanks will be modified Dortmund tank construction, similar to those recently constructed at Toronto, Canada. Provision can be made for treating the sewage, if necessary, with a coagulant before passing it into the tanks.

After treatment, the sewage will be discharged through a number of outlets arranged radially from the island in such position as to bring about the most immediate and perfect dispersion of the sewage practicable. If desirable, it will be feasible to pump sea water and mix it with the sewage before the discharge take place. Such admixture would facilitate the immediate diffusion of the sewage in the sea water; but the active agitation and free movement of the great volume of water in the vicinity of the island will, it is expected, make a preliminary mixture of sea water and sewage by pumping unnecessary.

The material which will settle out of the sewage in the tanks will be carried to sea in vessels and dumped sufficiently far from the land to insure that no trace will reach bathing beaches, inhabited shores or oyster grounds.

Provision will be made for a laboratory and dwelling house for those who will be needed to operate the tanks and other devices for the treatment and discharge of the sewage. It will be feasible to maintain a light on the island for the benefit of navigation, in case this is desirable.

In course of time, it will be necessary to increase the size of the island and it is proposed that this will be done by extending its

length so that the total area covered will be about three times that of the original island, or, approximately, 70 acres.

The quantity of sewage which will be brought to the island at the beginning is estimated at about 203,000,000 gallons per 24 hours during dry weather. During storms, this volume will increase about 100 per cent. This sewage will be collected from those parts of Manhattan and Brooklyn whose drainage is naturally tributary to the Lower East river between the Battery and 28th street, Manhattan. It is proposed to collect the sewage by building intercepting sewers close to the water front to receive the sewage from the existing combined sewers and gather it to a central pumping station to be located near the Brooklyn Navy Yard. A siphon built beneath the East river, will carry the sewage of Manhattan to the Brooklyn side. At the central pumping station the sewage will be pumped through a force main built as a tunnel to the island. The tunnel will be over 20 feet beneath the bottom of the Lower bay and so be free from injury to anchors even in the deepest parts of the channel between the island and the mainland where vessels rarely anchor. The sewage will consist of the ordinary dry weather flow except at periods of rainfall when the storm water from the streets will also be received to the extent of about once the volume of the average hourly production of house sewage.

65 All the sewage which is sent to the island will have been passed through grit chambers and screens with openings not larger than one-half inch. The sewage from Manhattan will be screened before passing to the Brooklyn side. Since it will be relatively fresh, it is estimated that no less than 15 per cent of the suspended matter will be extracted. Grit chambers will be located near the screens and their efficient operation will be insured by the necessity which will exist for removing the readily settleable material from the sewage in order to prevent obstructions in the siphon and interference with the pumps. The Brooklyn sewage will be passed through screens and grit chambers no less effective than those of Manhattan before the sewage is pumped through the force main. It is estimated that the settling basins on the island will remove at least 60 per cent of the suspended matter from the sewage. It is expected that the total effect of the treatment by grit chambers, screens and settling basins will be to remove considerably more than 75 per cent of the suspended matter originally present.

It is believed by this commission that either of the two locations here proposed for the island will be favorable for the sanitary disposal of the sewage and will be free from objection from the standpoint of navigation. Both sites are upon sand reefs where no vessels except fishing craft of lightest draft are likely to pass. The area of the island, even when extended to the dimensions which may ultimately be necessary, will be so small, as compared with the total area of the Lower bay, as not seriously to interfere either with the tidal prism or with the force or direction of the tidal currents flowing in and out of the harbor. The amount of solid matter contained in the sewage when discharged will be slight as compared with the volumes of water in the vicinity of the island and the action of

the waves and currents in this part of the harbor are so active that it seems improbable to this commission that deposits of any serious extent would be formed, even if the sewage was to be discharged in crude condition.

Apart from permission to build the island, which this commission would interpret as expressing a belief that no interference would be caused by the island to navigation, this commission would value the opinion of the Harbor Line Board as to the probable capacity of the island to resist the destructive action of the sea. It is recognized that the Army Engineers posses the qualifications of experts on this subject. If material criticism can be brought against the proposal of this commission for the construction of the island on the scope of structural defect, suggestions looking to a more durable form of construction would be regarded in the light of a public service.

Accompanying this letter is a chart of Lower New York bay, showing the two alternative locations for the proposed island, a profile giving the line of the tunnel through which the sewage would be pumped to the island, a plan of the island and three cross sections of the retaining walls.

Respectfully, GEORGE A. SOPER, *President.*

66 March 22, 1913.

Hon. George A. Soper, President Metropolitan Sewerage Commission, 17 Battery Place, New York City.

SIR: Referring to your letter of the 18th ultimo, submitting, for the views of this Department, a proposition of the Metropolitan Sewerage Commission of New York, as part of a plan for the disposal of the sewage of New York City by the construction of an island in Lower New York bay, I beg to inform you that the New York Harbor Line Board, to which the matter was referred, reports under date of 15th instant, as follows:

"The Board is of the opinion that an artificial island in the Lower bay between Coney Island and Sandy Hook in either one of the two locations shown on the map, and with the dimensions across the direction of the bay and flow of the tide substantially as shown, will not interfere unduly with navigation, nor have an unfavorable effect upon the harbor. Before issuing a formal permit it is suggested that the Sewerage Commission be requested to submit a map showing the approximate position and size of the island it proposes to build at the present time and proposed future enlargement, and the location of the sewers between it and the shore; also such details of the plan of the settling basin or other means for clarifying the sewage as may be necessary to show whether or not such plan will effectually prevent solid matter escaping into the channel in undue amount; also a profile of the proposed sewer showing the depth below low water along its entire route and beyond the crossing of Coney Island Creek."

The Chief of Engineers concurs in the views of the Harbor Line Board, and the map referred to showing dimensions, etc., is transmitted herewith.

Very respectfully, ROBERT SHAW OLIVER,
Assistant Secretary of War.

a COMPLAINANTS' EXHIBIT No. 203. James D. Maher, Commissioner.

NEW YORK CITY, May 19th, 1913.

This certifies that a copy of the within report has been filed in the Mayor's office by the Metropolitan Sewerage Commission.

JAMES MATTHEWS,
Executive Secretary.

Preliminary Reports on the Disposal of New York's Sewage.

VII.

Critical Reports of Dr. Gilbert J. Fowler, of Manchester, England, and Mr. John D. Watson, of Birmingham, England, on the Projects of the Metropolitan Sewerage Commission with Special Reference to the Plans Proposed for the Lower Hudson, Lower East River and Bay Division.*

Metropolitan Sewerage Commission of New York.

George A. Soper, James H. Fuertes, H. de B. Parsons, Charles Sooysmith, Linsly R. Williams, Commissioners.

February, 1913.

1 *Report of the Commission Introducing the Reports of Messrs. Fowler and Watson.*

Honorable William J. Gaynor, Mayor of the City of New York:

SIR: The reports here published represent critical studies by eminent experts who were called upon by the Metropolitan Sewerage Commission in the autumn of 1912, to examine various projects which the commission was considering for the protection of the Harlem and Lower East rivers against excessive pollution by sewage.

Preliminary plans had been prepared by this commission for the disposal of the sewage tributary to these bodies of water, but owing to the radical character of the remedies which seemed to be necessary, and the large sums of money involved, this commission considered it desirable to subject the projects to competent and unprejudiced criticism.

Messrs. Fowler and Watson were requested to come to New York and study the data which had been collected by this commission, remain long enough to become personally acquainted with the situation and to weigh the relative merits of the alternative plans which

*This report is issued in advance of the final report of the Metropolitan Sewerage Commission in order that the contents may be of early service.

had been made to improve the situation. The two experts came to America separately and made their studies independently of one another, although, while still in New York and, later, in England, they met and exchanged opinions.

Dr. Gilbert J. Fowler, who came first, is a chemist. He is a Doctor of Science, Fellow of the Institute of Chemistry, Fellow of the Royal Sanitary Institute of Great Britain and author of numerous reports, papers and contributions to the science and art of sewage purification. The sewage disposal works of Manchester, England, of which he is superintendent, have been developed under his direction until they constitute the largest plant of their kind in the world. These works include screens, settling basins, contact beds, sludge storage reservoirs and steam vessels for transporting the sludge to the open sea.

Mr. John D. Watson, who is a Member of the Institute of Civil Engineers of Great Britain and a Fellow of the Royal Sanitary Institute, is an eminent consulting engineer and expert in sewage disposal. He is in charge of the sewage purification works for Birmingham which are as large and efficient as any of their kind. Originally consisting of farm lands, where the sewage was taken for disposal in the hope of utilizing its manurial properties, these works have been rebuilt by
Mr. Watson in accordance with modern scientific principles
2 and include settling basins, sludge-digesting tanks, supplementary settling basins, percolating filters, screens and sludge-drying beds.

These two reports, which are of similar scope, therefore approach the subject from the separate standpoints of the chemist and the engineer. Each recognizes the necessity of stopping the existing pollution and improving the harbor without loss of time and critically discusses the nature and extent of the works which will be required. In each report the conclusion is reached that a large part of the sewage which is tributary to the Lower East river and Harlem should be collected in large sewers to be constructed near the water front and carried by tunnel to an island to be constructed in the sea at the mouth of the harbor, there to be discharged after enough of the impurities have been removed to insure that no nuisance or injury to health will result. This project was reported upon by the Metropolitan Sewerage Commission under date of January, 1913.

The standard of cleanness proposed by this commission in its report of August, 1912, is approved by Dr. Fowler and Mr. Watson as a code of minimum requirements. Mr. Watson, like some other sanitary experts who have been called upon to advise in regard to this standard, would have the harbor waters kept cleaner than the commission's requirements demand. Dr. Fowler discusses the present pollution in considerable detail and gives much attention to the need of cleanness with respect to these waters. Both experts lay emphasis upon the fact that the pollution has reached large proportions and is rapidly increasing.

The opinion is expressed by both that if the digestive capacity of the harbor for sewage is not to become overloaded to the point of nuisance, it will be necessary to carry a large part of the sewage away

for disposal, it being beyond the range of practicability to purify it near where it is produced.

It is pointed out that sewage works which are capable of effecting a high degree of purification are so likely to produce odors and nuisance from flies that it is desirable to avoid the construction of such works within the city limits as far as possible. For this reason only such comparatively crude and simple processes as employ settling tanks, grit chambers and screens should be considered for installation on the shores of Manhattan Island and Brooklyn. There is no land anywhere within the limits of Greater New York upon which it would be permissible to construct works capable of purifying the sewage tributary to the Lower East river and Harlem by percolating filters, such as Mr. Watson employs at Birmingham, or contact beds like Dr. Fowler uses at Manchester, because of the nuisance which would result.

After discussing other alternatives, Messrs. Fowler and Wat-
3 son arrive at the conclusion that the proper solution of the problem is this commission's proposal to carry the sewage which is naturally tributary to the Lower East river, and eventually that which is tributary to the Harlem, to an island to be built at sea. On this island the sewage would be passed through settling basins and perhaps treated with electrolyzed sea water, in accordance with a method with which the Metropolitan Sewerage Commission has made some experiments. The effluent from the island should be discharged in such a way as to cause the organic matters present to be thoroughly mixed with large quantities of fresh sea water and, consequently, oxidized and rendered permanently harmless and inert by natural agencies.

Neither Dr. Fowler nor Mr. Watson has been dissuaded from endorsing this project on account of its cost. Their opinion is that the money for such sewage works as are necessary for the health, welfare and reputation of the port will be forthcoming, when once their necessity is understood. It is pointed out that other cities, and among them many small places, have spent much more per capita for sewage disposal than would be required here.

Mr. Watson has given considerable attention to the form of administration which is most suited for the construction and maintenance of the necessary main sewers and sewage disposal works and his experience as Chief Engineer of the Birmingham, Tame and Rea District Drainage Board, which represents a number of municipalities in addition to Birmingham, gives him special qualifications to deal with this subject. He recommends that a commission be created which shall have charge of the building and maintenance of such sewage disposal works as are necessary for New York and in this suggestion, Dr. Fowler, with a knowledge of the details of the recommendation, concurs.

The reports of Messrs. Fowler and Watson contain so much that is of value from scientific and practical standpoints and their statements seem so capable of aiding the public to understand New York's large

and complicated problem of sewage disposal that their two reports are herewith published in full.

Respectfully submitted,

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK.
GEORGE A. SOPER, *President.*
JAMES H. FUERTES, *Secretary.*
H. DE B. PARSONS.
CHARLES SOOYSMITH.
LINSLY R. WILLIAMS.

February, 1913.

4 *Reports of the Metropolitan Sewerage Commission.*

1. Digest of Data Collected Before the Year 1908 Relating to the Sanitary Condition of New York Harbor; 87 pages; 1909.
2. Report on the Discharge of Sewage from the Proposed Passaic Valley Sewer of New Jersey; 7 pages; May 23, 1910.
3. Report on the Proposed Discharge of Sewage from the Bronx Valley Sewer; 10 pages; July 25, 1910.
4. Sewerage and Sewage Disposal in the Metropolitan District of New York and New Jersey; 550 pages; April 30, 1910.
5. Present Sanitary Condition of New York Harbor and the Degree of Cleanness which is Necessary and Sufficient for the Water; 457 pages; August, 1912.

Preliminary Reports on the Disposal of New York's Sewage:

6. I. Study of the Collection of the Sewage of New York City to a Central Point for Disposal; 16 pages; September, 1911.
7. II. Description of the Four Principal Drainage Divisions in that Part of the Metropolitan Sewerage District which Lies in New York State; 11 pages; November, 1911.
8. III. Study of the Collection and Disposal of the Sewage of the Jamaica Bay Division; 10 pages; November, 1911.
9. IV. Study of the Collection and Disposal of the Sewage of the Upper East River and Harlem Division; 17 pages; July, 1912.
10. V. Study of the Collection and Disposal of the Sewage of the Richmond Division; 21 pages; September, 1912.
11. VI. Study of the Collection and Disposal of the Sewage of the Lower Hudson, Lower East River and Bay Division; 58 pages; January, 1913.
12. VII. Critical Reports of Dr. Gilbert J. Fowler of Manchester, England, and Mr. John D. Watson of Birmingham, England, on the Projects of the Metropolitan Sewerage Commission with Special Reference to the Plans Proposed for the Lower Hudson, Lower East River and Bay Division; 33 pages; February, 1913.

5 *Report of Gilbert J. Fowler, D. Sc.*

To the President and Members of the Metropolitan Sewerage Commission of New York.

GENTLEMEN: In accordance with the request of the Metropolitan Sewerage Commission, conveyed to me by the President, Dr. George A. Soper, in a letter dated September 27th, 1912, I arrived in New York on the 10th November, 1912, and remained, with brief absences in Boston, till Wednesday the 27th November.

During this time the following inspections were made:

By water: 1. Upper bay,
2. East river to Long Island sound,
3. Round Manhattan Island,
4. Through the Narrows to Far Rockaway and into Jamaica bay.

By land: 5. To Gravesend bay, Coney Island, Sheepshead bay and Canarsie, visiting disposal works at Sheepshead bay, Paerdegat basin and 26th Ward,
6. To Newtown creek, returning to Manhattan, recrossing the Lower East river below Hell Gate and skirting the edge of the Upper East river including Steinway, Flushing bay, Whitestone and Douglaston.

I also visited Boston, and through the courtesy of the Massachusetts Board of Health, was able to inspect the three types of sea outfall there. The same day I visited the Lawrence experimental station and discussed the work being done with the chief chemist. On these various expeditions numerous photos were taken of important points such as some of the larger sewer outlets, proposed places of discharge &c.

A good deal of time was spent in the laboratory of the commission overlooking and discussing experiments on the possibilities of electrolysed sea water as a precipitating and sterilising agent for the sewage. I also had much conversation and discussion with reference to the data accumulated by the commission, and was shown numerous data hitherto unpublished, especially in reference to the possibilities of complete nitrification taking place in mixtures of sea water and fresh water.

6 The President was good enough to demonstrate for me the method used by the commission in their fundamentally important work on the dissolved oxygen in New York harbor. The method is rapid and accurate and well suited to the conditions of investigation. I have carefully studied both before and since my visit to New York the extensive and valuable reports issued by the commission as well as the report by Major Black and Prof. Phelps.

Immediate Conclusions.

I was impressed at the outset by the vastness and complexity of the problem to be dealt with. London may have a larger present population but the conditions for discharge are infinitely simpler.

In addition to the rapidly increasing population directly or indirectly discharging its sewage into the harbor, the problem is complicated by the outstanding facts, viz:—(1) the growing scarcity and value of unbuilt upon land in the vicinity of the harbor, (2) the comparatively small amount of water available for flushing out the bay, this being limited practically to the flow of the Hudson. The thickly populated districts abutting on the Harlem river and the Lower East river discharge into waters which ebb and flow with the tide, but suffer very little actual change, little or no excess water passing out of the bay or into it at each tide.

As a consequence, the conditions to be met with in the Harlem and Lower East rivers call for immediate action. Not only is the bottom polluted, but the water, even in favorably situated portions of these rivers, is deficient in oxygen, in the majority of cases to nearly 50 per cent. In many places there are local nuisances already, and floating fæcal matter, paper, &c., are in frequent evidence. What the conditions are likely to be when the surrounding districts, increasing as they are now doing, to say the population of 1940, it is not pleasant to conjecture. It is evident that something will have to be done here and done at once. When the volume of sewage to be dealt with, over 350 million gallons per day at the present time, and more than 700 million gallons by 1940, is considered it is evident that for this section of the work alone considerable expenditure will have to be faced.*

In view of the very large expenditure involved, it is difficult to exaggerate the importance of adequate preliminary studies and the work of the commission throughout appears to me to be a model of the way in which such investigations should be carried out.

7 The conditions are so complicated, owing to the diversified character of the land and water areas constituting New York harbor and its surroundings, that endeavors to reproduce them artificially, as is often done in research work, are likely to be only partially successful. The method of thoroughly studying the actual state of things obtaining in the bay and other waters in the vicinity under all conditions of season, tide and weather, as has been done by the commission, seems the only possible one, and the work has been done with masterly completeness. No question necessary for the formation of a right judgment on the questions which should be settled at this time appears to have been left unstudied by the commission.

The citizens of New York may rest assured that the large sum of money they will be called upon to pay for the protection of their harbor will not be asked for except as the result of opinions formed

* Report Metropolitan Sewerage Commission of New York, August, 1912, p. 28.

after years of study much more complete than is generally given to such a subject. Every year, however, the conditions now existing must necessarily grow worse and, while in the case of a growing science like that of sewage disposal it is well to hasten slowly, yet through the labors of the commission there will exist no justification on the score of imperfectly known data for postponing certain most necessary works.

Principles Governing Consideration of the Problem.

The conditions which must be realized if the constituents of sewage are to be rendered inoffensive or finally mineralised are essentially the same whether the disposal be by irrigation upon land, filtration through artificial biological filters, or dilution with fresh or salt water. The process is in all cases one of oxidation, i. e., practically speaking, combustion, and if it is to be conducted without nuisance, enough oxygen must be present at all stages of the process to prevent the formation of evil smelling products.

It is perfectly legitimate to use the oxygen dissolved either in sea or river water in order to oxidise sewage. Under proper conditions of discharge, complete transformation and mineralisation of the sewage matters can be effected in this way with less nuisance than often accompanies treatment on filters or on land.

The question of the margin of safety which should be allowed if nuisance is to be avoided has been the subject of reports by a number of well-known experts to the Metropolitan Sewage Commission * and all of these reports agreed that under no circumstances should the dissolved oxygen in the harbor be allowed to sink to below 50 per cent. of saturation. In this opinion I concur. It will, however, be most unwise to be content with a margin simply sufficient to barely eliminate nuisance.

Two main considerations govern the situation from the point of view of public policy; these may be described as considerations of Health and Welfare.

Health.—There are obvious ways in which public health may be directly affected by the filthy conditions of parts of the harbor or even by the apparently innocuous discharge of sewage or sewage effluent.

It is not a pleasant sight to see numbers of floating fæces wasihng in and about piers where food supplies are landed from lighters some of which have a low free board. Gulls and flies may also quite possibly be carriers of infectious material under such conditions.

The question of oysters is of more direct importance. Even if sewage or sewage effluent is actually sterilised, the growth of oysters near an outfall is always a possible source of danger, and while it is quite easy to exaggerate this, yet it can never be in accordance with right sanitation for an article of food to be thus contaminated.

The pollution of bathing sites has been dealt with at length by

* Report Metropolitan Sewerage Commission of New York, August, 1912, pp. 69-164.

the commission.* The conditions which at present exist are unsatisfactory in the extreme.

The carrying of polluted driftwood daily into the homes of the poor in the neighborhood of the water front does not tend to raise the standard of cleanliness in such homes and should be prevented rather by stopping pollution than by forbidding what is in itself a reasonable and thrifty proceeding.

But even more important than the direct and obvious ways in which the public health is affected by the polluted condition of the harbor waters, is the practically unconscious lowering of that sense of decency and cleanliness of living which must be maintained if the efforts of social reformers are to have any serious result.

Crowds of people from the poorer quarters of New York throng the recreation piers and pleasure drives on the water front. If it is obvious to them that those in authority, who have the power, are yet unconcerned to abate uncleanly surroundings, the already not inconsiderable effort required to maintain a decent spot of home life in a mean environment, will be rendered even harder to achieve.

Welfare.—The second consideration, viz., that of welfare, as it has been termed, is perhaps less obvious, but is most important when expensive works, the use of which is partly for future generations, have to be considered.

9 A study of the history of sanitation, such for example, as was possible in the historical section at the International Hygiene Exhibition in Dresden in 1911, will show that, up to comparatively recent times, conditions were tolerated which to us would seem unspeakable. Yet even now the standard of requirement is constantly rising. One may, indeed, frankly say that the modern American bathroom both in its fitting and the frequency with which it is to be found is a distinct advance upon what is common even in England. Such a bathroom, however, increases the difficulty of the sewage problem, and in looking forward to the future, similar advances in public requirements must always be reckoned with. The idealism manifested in such great buildings as the Pennsylvania Railroad station and the Metropolitan Museum of Art and the parks and playgrounds of the city will find its further development in a demand for brightness and beauty in the surrounding water spaces. Nor is such idealism unrelated to mere purely economic prosperity. The true solution of any problem is true at all points, sanitary, æsthetic, ethical and economic.

Apart from the question of affecting the vitality, and consequent wage earning capacity of the people, the reputation of a port is a very essential factor in its commercial prosperity. The condition of the Clyde and of the Manchester ship canal was for many years a by-word. The great sewerage and sewage disposal works at Glasgow carried out at a total cost of over £2,000,000 for 800,000 people have been the means of rehabilitating the reputation of the Clyde

* Report Metropolitan Sewerage Commission of New York, April 30, 1910, pp. 486-497.

and adding to the amenities of life, pleasure trips being now possible from the Bromielaw to the Firth of Clyde.

The large amount of money spent on sewage works in the watershed of the Mersey and Irwell is, apart from the increasing expenditure of Manchester itself, slowly but steadily improving the water of the Manchester ship canal.

At one time the stench from the polluted Thames in hot weather rendered the committee rooms in the houses of parliament in London uninhabitable. By the removal of the sewage to treatment works and outfalls lower down the river this nuisance has been abolished, and London is now one of the healthiest and best drained cities in the world.

In the case of the three cities above referred to, their works were carried out under urgent pressure of obvious and almost intolerable nuisances from the polluted streams. New York should deal with her problem before such acute conditions arise.

The foregoing general view of the situation clearly indicates that any scheme which is decided upon must not block the commercial avenues of the future. It must be so designed as to be capable of expansion as the needs of the city increase.

10 Possible Methods of Dealing with Sewage.—The various possible methods which are available for dealing with sewage on the large scale may be broadly divided into:—

1. Direct discharge into water.
2. Discharge after screening.
3. " " sedimentation.
4. " " chemical treatment.
5. " " filtration in some form,
6. " " combination of processes.

The proportional amount of impurities removed by these processes depends on numerous factors, e. g., the freshness and strength of the sewage. Thus, screening will remove a much greater proportional amount from very fresh sewage than from sewage which has been mixed and churned up for many miles in a trunk sewer. Chemical treatment is more economical with strong sewage than with weak, and therefore is of less advantage with American sewage than with European.

Very roughly, it may perhaps be assumed that under the conditions existing in New York, of the nuisance-producing solid material in sewage capable of producing deposits of sludge, the following percentages can be removed by the respective processes:—

Screening and grit chambers	3-6 per cent.
Short sedimentation	50 "
Chemical treatment	75 "

None of these processes seriously affects matters in solution. Filtration affects not only the finely divided colloidal matter still present after the foregoing processes but also oxidises substances in solution.

Which of these methods can be used at any of the various proposed points of outfall in New York harbor is to be determined by local conditions. What these conditions are is considered in the next section.

The Present Polluted Condition of the Harbor.

Broadly, the waters of that part of New York harbor which lies in New York State may be considered separately as follows:—

The Hudson river,
The Upper bay,
The East river and the Harlem river.
Jamaica bay.

11 Of these, the Hudson river contains the most dissolved oxygen, this amounting to over 90 per cent. of saturation in the centre of the river in the northern part of Manhattan and diminishing to 60 per cent. near the Battery. The Hudson river supplies practically the only water available for flushing the harbor. All along the edge of the Hudson among the piers objectionable conditions exist.

The Upper Bay.—All the pollutions from the waters entering the harbor at certain states of the tide, as well as those resulting from direct sewer discharges are mixed by tidal currents in the Upper bay and a proportion of the solid matters is doubtless deposited there during the ebb and flow of the tide. This is evidenced by the polluted character of the dredgings from the bottom of the Upper bay at nearly every point of observation. Considerable deposit of sludge has been found south of Governor's Island.

The general appearance of the waters of the Upper bay is by no means attractive. Large fields of sleek, or oily film, are frequent and, more objectionable, are masses of floating debris in which large quantities of fæcal matter are often entangled. The Gowanus canal is but little better than an open sewer, there being an insufficient circulation of water to dilute the large volumes of sewage discharged into it.

The East River and the Harlem River.—It is on these rivers, especially in the Lower East river and the Harlem that, as already stated, conditions exist which call for urgent remedy.

Large sewers discharge from the thickly populated districts on both sides of these waterways and there is little or no net tidal discharge. As a result, the bottom of the upper East river as far as Throg's Neck at the entrance to Long Island Sound is foul, and in the Lower East river, in places unaffected by the ebb and flow of the tidal currents, foul deposits occur.

In the Lower East river from the Williamsburg Bridge to Hell Gate the dissolved oxygen present, especially in the summer months is not much more than 50 per cent. of saturation.* In some parts

* In the summer of 1912 some samples of water from the Lower East river, near the Brooklyn Bridge, were found to contain 43 per cent. of oxygen.

of the Harlem river it is less than this. There are portions of the Harlem river already approaching the condition of the Manchester ship canal, while Newtown creek has practically reached that condition. In the vicinity of Wallabout basin there is a large sewer outlet which produces a small lake of sewage in its vicinity, which is most objectionable.

There is no doubt that if the sewage which now enters crude into the Lower East river and the Harlem river could be taken up
12 and dealt with in a satisfactory manner, very great benefit would accrue not only to these waterways but also to the Upper bay and Upper East river into which much of the sewage eventually finds it way.

Jamaica Bay.—The characteristic feature of Jamaica bay and its vicinity is the growing summer population of numerous pleasure resorts, such as Bergen Beach, Arverne, Edgemere, Canarsie and Rockaway. The conditions which I saw in November were, therefore, hardly typical. Effluents from treatment works at Sheepshead bay and the 26th Ward, though obviously imperfectly purified were not the cause of serious visible pollution.

In view of the increasing population and of the schemes of harbor development which are being considered, it will be necessary before very long comprehensively to deal with the sewage which at present discharges into the bay.

The question of oyster pollution must here, also, be dealt with and it should be clearly understood that ordinary methods of treating sewage give little protection from a bacteriological point of view, while processes of sterilization may easily produce a false sense of security. It would seem best for oysters not to be taken near densely populated centres, as under such circumstances the chances of pollution, apart from the sewage which is discharged from actual sewage outfalls are considerable.

Proposed Remedies.

Sewage Tributary to the Lower East River and Harlem River.—As already emphasized, the first point of attack in dealing with the problem of purification of New York harbor is the Lower East river and the Harlem river, and I have given my most careful consideration to this part of the commission's work.

After much study the commission have concluded, and I think rightly, that the only point where large quantities of sewage can be treated in this neighborhood is at Ward's Island. It is possible to pick up the sewage which at present discharges into the Harlem river and also that which is turned out of the large sewer at Hunt's Point and bring it all to Ward's Island where it can be treated in settling tanks and the heavier sludge removed.

Some 124 million gallons daily would be thus dealt with at once, and over 400 million by 1940,* and would be discharged into the

*Preliminary Repoort IV, of the Metropolitan Sewerage Commission on the Disposal of New York's Sewage, July, 1912.

swift tidal currents at Hell Gate where the best possible conditions exist for mixing.

13 Sedimentation, however, leaves a large proportion of potential solids still present as well as all the impurities in solution. Treatment by chemicals instead of by plain sedimentation would remove a further proportion of the suspended impurities, but the treatment in this way of such large volumes of sewage as may be taken there involves numerous difficulties and greatly increased cost, which would weigh heavily against the advantages obtained. Further purification, by filtration, at Ward's Island is impracticable, and also not to be recommended so near large centres of population owing to the possibilities of ærial nuisance and fly trouble on large areas of filters.

It becomes matter, therefore, for careful consideration how far the concentration of the sewage to one point and discharge into the local waters after elimination of the grosser solids would really relieve the situation. It is to this point that most careful thought has been given and the bearing of all the available data studied under every aspect.

Owing to the fact that the waters rushing through Hell Gate only pass back and forth with the tide and do not really get away to the ocean, it is evident that whatever sewage is discharged at Hell Gate is largely dependent for its oxidation on the oxygen in the water with which it mixes in one tide. The Lower East river is, however, highly polluted and the discharged effluent will therefore not get much help from it. The situation, in fact, is only improved by the elimination of the grosser solids from the sewage of the Harlem district. If the situation is to be radically improved, the conclusion seems inevitable that some sewage must be removed from the Lower East river.

From figures supplied me by the commission, I calculate that if the sewage of the Harlem territory is collected and passed through settlement tanks on Ward's Island, and if the sewage of those parts of Brooklyn and Queens which would ordinarily discharge into the Lower East river be removed altogether, there will then be a dilution representing 1 of raw sewage to 200 of water in the Lower East river at mean low tide.

This is a considerable improvement on present conditions, representing a removal from the Harlem and Upper and Lower East rivers, together with about 50 per cent. of the total sewage which at present pollutes them.

It is, however, from the Manhattan waterfront that the greatest proportional volume of sewage enters the Lower East river. It exceeds the volume discharged into this division of the harbor from Brooklyn and Queens by about 50 per cent. The further conclusion, therefore, is forced upon one that a really satisfactory solution of the problem must involve the removal of this sewage also. Indeed a study of the statistics show that if this is not done, the Lower East river in 1940, will revert to a condition even worse than exists to-day.

14 Disposal at Sea of that Part of the Sewage of Brooklyn, Queens and Manhattan Which Would Ordinarily Discharge into the Lower East River.—The conditions discussed in the foregoing section show clearly that the sewage from these districts will have to be removed from the Lower East river if the situation is to be properly dealt with.

From the researches of the commission there would appear to be three possible outlets for this sewage.

The first possibility is to take it to Barren Island and there treat it in tanks, followed, possibly, by some form of filtration and discharge it near the entrance to Jamaica bay. At the same point would be collected the sewage now very imperfectly dealt with at the various sewage works discharging into the creeks on the northern shore of Jamaica bay. The point of outlet would be at the entrance to Jamaica bay.

Barren Island itself is, however, little more than half a mile from the large summer population on the Rockaway peninsula, and if, as is not at all improbable in hot summer weather, some amount of smell should arise from the filters, it is not far enough away to prevent a nuisance to these people. Moreover, the point at which the effluent would discharge is not half a mile from thronged bathing beaches. There are therefore these grave objections to an outlet near Barren Island.

A second alternative proposition has been considered, viz:—the removal of the sewage to the west side of Staten Island, with the erection of purification works there. Apart from engineering difficulties which I am informed exist in carrying so much sewage across the very deep channel of the Narrows, the conditions of final discharge would render purification by biological filters necessary, and similar objections would again arise in regard to nuisance from these as have been pointed out in regard to the Barren Island project.

Under these circumstances a third alternative has been suggested which seems to me to have much to recommend it. This proposition is to build an artificial island well out in the Atlantic, nearly three miles from the shore of Coney Island, and there construct settling tanks, and discharge the effluent after settlement of the bulk of the suspended solids, into deep water, with proper engineering precautions to ensure thorough mixing of the effluent with the seawater.

After inspection of the Boston sea outfalls I am clearly of the opinion that no point of outlet should be less than 40 feet in depth, and that the discharge should be continuous so as to minimize the quantity sent out in any interval of time.

15 The sludge deposited in the tanks could be readily taken well out to sea in tank steamers of the pattern used in Europe, as at Glasgow, Manchester, Salford and London.

I understand that the island can be made without difficulty from the spoil and debris from excavations in New York city at present taken out to sea, or from sand pumped from the bottom of the sea,

I understand, also, that it will be possible to increase the number and length of the outfall pipes as more and more sewage is coupled up to the island, so that the effluent will always be well distributed in the sea water. The operations can be carried on without causing nuisance to any one, the conditions for sea disposal of sludge in tank steamers are very simple. The scheme is capable of indefinite expansion as more sewage is taken up, as the size of the island itself can be increased as extensions to the works are required.

Many matters rather of detail remain for further consideration in regard to the methods of treatment employed both at what may be termed "Atlantic" Island and Ward's Island. The design of the settlement tanks to be employed is a question of importance. A form of tank is to be preferred which would expose as little water surface as possible and also allow automatic removal of the sludge by the pressure of the supernatant water. A modified form of two-story tank would seem well suited to this purpose.

The sludge produced by the thorough fermentation which takes place in the so-called Emscher tanks, while greatly reduced in bulk and offensiveness, would offer some difficulties in carrying to sea, owing to its being saturated with gas. It is possible that judicious admixture with salt water would obviate this difficulty. In any event the disposal of sludge is not the least difficult part of the problem. There will not be more, for a long time at any rate, than is at present handled at the London outfalls, and the conditions of sea disposal are simpler in the case of New York.

For reasons indicated when referring to works on Ward's Island, I do not recommend treatment by chemical precipitants. I think, however, that very careful study deserves to be given to the practicability of adding a small dose of chlorine to the effluent, e. g., by the addition of a certain volume of electrolysed sea-water. This would serve the double purpose of deodorising what may be a somewhat malodorous effluent after its long travel through the sewers, and a further important advantage would lie in preventing an immediate call upon the dissolved oxygen in the sea at the point of discharge, and thus giving time for more thorough mixing and aeration to take place.

Some Further Problems.—There are many matters of importance, subsidiary to the large scheme outlined above which call for brief mention.

16 A system of screens and catchpits has been designed for Manhattan Island, which could afterwards be used for screening storm water, overflowing from the main sewers later to be built. It is in my view important that this should be carried out, in order that even after large sums have been spent on main sewers and outfall works, there should not be public disappointment, when visible pollution is seen to be present after every shower of rain. Before such refuse is removed, however, means must be at hand for its rapid incineration in suitably placed destructors.

The scheme of outfalls and outfall works designed by the commission for the districts abutting on the Upper East river seems to

me to be adequate, at any rate, for many years. The outlets are all in deep water and the conditions resemble those of the Clyde summer resorts or English lakes, where the sewage of a fairly large population is disposed of without serious difficulty.

Time did not permit me to study the problems connected with Staten Island actually on the spot. From a perusal of the commission's report on the disposal of the sewage of the Richmond Division there would not appear to be any special difficulty in dealing with the situation as far as regards the responsibility of New York City.

In the Arthur Kill and Kill van Kull we are approaching the problems of New Jersey. I have not been called upon to express an opinion on matters which are a subject of litigation. One may, however, safely say that a resolute handling by New York City of her own problems is likely to facilitate an equitable conclusion.

Summary and Conclusions.

After careful consideration of the situation as it has been placed before me I am of opinion that the sewage of the Harlem district should be collected and treated in sedimentation tanks on Ward's Island.

This will relieve the immediate and pressing situation on the Harlem river. It will, however, do little or nothing to improve the Lower East river.

It is of equal importance, therefore, that the scheme be pressed forward of driving a main sewer southwards through Brooklyn to an artificial island well out from shore in the Atlantic ocean, where tanks could be built for settling out the heavier suspended matters and removing them to sea.

Into this main sewer would first be discharged that part of the sewage of Brooklyn and Manhattan which at present passes in a crude state into the Lower East river. Later, more of the sewage of Manhattan should be coupled up to this sewer, the outlets at the artificial island being extended with each large increment of sewage.

17 Next, the sewage from the Jamaica Bay Division might be brought to the island and finally, if thought desirable, the sewage which, during all this time had received treatment at Ward's Island.

By this sequence of procedure the experience gained at Ward's Island would be of value in designing the final disposal at the "Atlantic Island," and at any rate a large proportion of the money expended in tanks, &c., at Ward's Island will have been redeemed before the works are abandoned. The expenditure in sewers in the Harlem district will be for permanent works alone.

The order of carrying out the various needful works and the time over which the construction should extend would all be matters within the control of the permanent commission suggested by my colleague, Mr. Watson, with whose views on this aspect of the question I heartily concur.

This same central board or commission would care for the other

less immediately pressing, but still highly important, problems referred to in the later paragraphs of the foregoing report.

The above represents in broad outline the lines upon which, in my opinion, the City of New York should proceed in its endeavour to obtain a harbor worthy of itself.

It must again be emphasized that no time should be lost in setting about the actual carrying out of the scheme. It must of necessity take a number of years to complete, and equally of necessity the condition of the harbor waters must become progressively worse if nothing is done, and will indeed probably be worse before the first instalment of the work is completed.

I am, however, confident that the citizens of New York will show the same determination and largeness of outlook already manifested in their great water supply projects, their colossal railway undertakings, and magnificent bridges and public institutions, in this further effort after social well-being, and will build the works necessary to cleanse the harbor and make it worthy in every respect of its great position as the Gateway of the West.

Respectfully submitted,

GILBERT J. FOWLER.

Manchester, February 10, 1913.

18 *Report of John D. Watson, M. Inst. C. E.*

To the President and Members of the Metropolitan Sewerage Commission of New York.

GENTLEMEN: I have given the problem of the sewerage and the sewage disposal of your great city my close and careful consideration during the past two months.

The fortnight which I spent in the city in the end of November and beginning of December gave point and animation to the study which was not otherwise possible, and I take this opportunity of thanking you for the ready access you gave me to all your documents, plans, and analytical figures, and for the facilities with which you provided me in the inspection of every part of the area which I thought it essential to visit. Allow me also to record my appreciation of the exhaustive preliminary investigations which you have made. These far exceed anything which I have hitherto had experience of, and the fact of your having printed them renders unnecessary reference to details which otherwise would have had to be given in this report.

The Polluted Condition of the Harbor.

If there were any prospect of limits being set to the bounds of New York, if there were any signs that sufficient accommodation had already been made for the shipping of the port, or if the waters of the harbor were so foul that the citizens had ceased to regard them as valuable for other than utilitarian purposes, the disposal of the sewage—vast as the volume of that is—would be comparatively easy.

But it is quite otherwise. The city is more than the capital of a country; it is the greatest city of a continent. The harbor is the gateway to the United States, and the noble rivers which find a ready outlet into it form, with the harbor proper, a port which affords at all stages of the tide no halting welcome to vessels of the greatest burden.

When I first had the pleasure of seeing the Hudson between Albany and New York, I was greatly impressed by its grandeur and its purity; when I motored along its left bank from Riverside Park toward the city boundary at Yonkers in brilliant sunshine, I thought it the Queen of Rivers, and I cannot believe that the average citizen would willingly allow it to become visibly polluted with sewage, yet the facts to which I shall refer will prove that it is necessary to take steps now to guard against such a contingency in the immediate future.

19 Visible Pollution.—The numerous analyses of the harbor waters made by your own officers, supported by men of such eminence as Professor Phelps, Dr. Adeney and Dr. Fowler, and the clear evidence of pollution which I have witnessed, lead me to the opinion that continuance of the present unhampered license to pollute can only lead to disaster. When it can be shown that even now the condition of the harbor in summer is obviously unclean, it is only a question of time when an ever-increasing population discharging an incremental amount of sewage and trade waste into what must be practically a stationary volume of harbor water will convert into a nuisance what should be one of the brightest and best of the city's possession.

One of my first actions in prosecuting this study was to investigate the condition of the harbor water, and even in the end of November I found at several places a slight smell of sewage. In ferrying across the river between 92nd Street and Astoria I observed innumerable particles of paper and even pieces of excrementitious matter in the water. Sea gulls indicated where the public sewers debouched directly into the river.

In many places in the East, the Harlem and the Hudson rivers, the Gowanus and Wallabout bays, visible evidence of the presence of sewage was only too apparent. Near the Battery I saw food which had just been unloaded from a boat that was moored in what looked more like sewage than clean water. At another place (Gowanus canal) I witnessed the ebullition of gas apparently arising from septicized sewage sludge. Large flows of greasy sleek and debris were to be seen at frequent intervals. Open ends of sewers spewing their filthy contents into the rivers are of much too frequent occurrence.

One and all demonstrate the same lesson that the time has arrived when a standard of cleanness should be set and maintained. If such conditions were offensive in November and December, it is obvious that they must be worse in the hot seasons of the year. Of course offensiveness to sight and smell do not necessarily constitute a nuisance which is dangerous to health, but as no self-respecting com-

munity would tolerate streets that were rarely scavenged because no injury to health could be traced to them, no port of the first rank should permit excrement paper, straw and grease to flow to and fro on the surface of the chief highway into the city because it could not be proved that a human being had died as the result.

The Proper Standard of Cleanness.—The standard of cleanness which you suggest, and which I heartily approve, should be reasonably but strictly enforced.* Liquid pollution, although less obtrusive, is not less in need of prevention, and it is in the interest of the community to see that any recognized standard which may be decided upon should be conscientiously adhered to. What the standard should be is a question which you have already submitted to a number of well known experts, and they have all united in saying that the dissolved oxygen in the harbor water should not be allowed to fall below 50 per cent. or 60 per cent. of the saturation limit. Colonel Black and Professor Phelps suggested that it should not be allowed to fall below 70 per cent. saturation, and this figure is more in accordance with my own view; indeed I go further and say that an even higher standard is feasible if the project recommended later in this report is approved and given effect to.

The result of 289 samples tested by you for dissolved oxygen in the summer of 1911 show clearly the polluted state of some parts of the harbor. Taking 100 per cent. as the saturation point, or the normal condition of clean water, the following comparison of average figures speak volumes:—

---

* Report Metropolitan Sewerage Commission of New York, August, 1912, page 70.

20 **Standard of Cleanness.**

1. Garbage, offal or solid matter recognizable as of sewage origin shall not be visible in any of the harbor waters.

2. Marked discoloration or turbidity, due to sewage or trade wastes, effervescence, oily sleek, odor or deposits, shall not occur except perhaps in the immediate vicinity of sewer outfalls, and then only to such an extent and in such places as may be permitted by the authority having jurisdiction over the sanitary condition of the harbor.

3. The discharge of sewage shall not materially contribute to the formation of deposits injurious to navigation.

4. Except in the immediate vicinity of docks and piers and sewer outfalls, the dissolved oxygen in the water shall not fall below 3.0 cubic centimeters per litre of water.† Near docks and piers there should always be sufficient oxygen in the water to prevent nuisance from odors.

5. The quality of the water at points suitable for bathing and oyster culture should conform substantially as to bacterial purity to a drinking water standard. It is not practicable to maintain so high a standard in any part of the harbor north of the Narrows or in the Arthur Kill. In the Lower bay and elsewhere, bathing and the taking of shellfish cannot be considered free from danger of disease within a mile of a sewer outfall.

---

† With 60 per cent. of sea water and 40 per cent. of land water and at the extreme summer temperature of 80 degrees F., 3.0 cubic centimeters of oxygen per litre corresponds to 58 per cent. of saturation.

Lower New York bay	98	per cent
Long Island Sound near Throgs Neck	96	"
Hudson river, a few miles above Manhattan Island	81	"
Narrows	73	"
Upper East river	71	"
Kill van Kull	66	"
Hudson river to north of Manhattan Island	64	"
21 Upper New York bay	63	per cent
Lower East river	55	"
Newark bay	54	"
Harlem river	42	"

Average figures in such a study do not quite suffice, for as the strength of a chain is the weakest link, so the lowest figures obtained (30 per cent at the lower end of the Harlem in July, 1911) indicate the danger conditions which sanitarians would strain every nerve to avert.†

The Increasing Discharge of Sewage.—When one remembers that the population of New York was only 2,500,000 in 1890, and that in 1905 it was 4,000,000, a careful estimate of its probable growth in the future is essential to arrive at a wise judgment in the matter of sewage disposal.

Estimates have been made by several authorities, including Freeman who said the population in 1940 would be..... 7,652,000
and Laidlaw who said it would be..... 8,662,829
The New York Telephone Company's estimate is..... 8,747,000
and the Board of Water Supply's estimate is..... 9,258,600

The average of these suggest a probable population of the city in 1940 of 8,580,107, a figure which proximates to your own estimate of 9,000,000, which be it remembered is based on the Census figure of 1910, and on this account is more likely to be accurate.

The prospective population which should be reckoned, however, is not 9,000,000 but 12,000,000, the population of the metropolitan area. The question as to what extent the harbor is likely to be burdened with impurities in 1940, assuming that nothing is done in the interval, depends on population more than anything else, and whether that population is located north, south, east or west of the harbor makes no difference. Artificial boundaries, therefore (state or other), are obviously not so important to the issue as watershed, and far fetched as it may appear to be at first sight the manner of disposing of the sewage of the City of Albany and every other populous place built and to be built on the banks of the Hudson will materially affect the problem under consideration. This will be apparent if it is conceded that the recuperative influence of the har-

† The percentage of oxygen fell still lower in 1912. The average for the year: Hudson river off Pier A, 55 per cent.; Narrows, 70 per cent.; Kill van Kull, 65 per cent.; Upper New York bay, 64 per cent.; Lower East river, 47 per cent.

bor depends very largely upon the purity or otherwise of the Hudson as it enters New York City.

22 The act of assimilation can be carried on only in the presence of oxygen, and it is therefore essential to conserve that oxygen as much as possible.

The table which I have quoted to show the relative state of purity at various specified places as measured by percentage of loss of oxygen is eloquent condemnation of the existing system, a condemnation which is only partially mitigated by the naturally and wonderfully even admixture of the harbor water as shown by the voluminous observations you have made.

In studying this question the fact that the volume of sewage must increase constantly has to be set in juxtaposition with the fact that the clean water from whence the oxygen is derived must remain very much the same in all time. Nor should the floating population as represented by the trade of the harbor be ignored. This is certainly a difficult problem, and I fear it will be impossible to exclude sewage from this source altogether; it is the more important, therefore, that the authorities deal effectively with the sewage from the stationary population which is under control.

Cleanness, a Commercial Necessity.—On the day I arrived in New York the newspapers referred to a remarkable speech by the Mayor on the subject of the growth of imports and exports at several harbors of the United States. The occasion for this speech was the 144th anniversary of the organization of the Chamber of Commerce, and it was shown that the increase of trade at New York was far and away greater than at any other port in the country.

Since 1898 the increase at the port of New York was									111	per cent.
"	"	"	"	"	"	"	"	Philadelphia "	75	per cent.
"	"	"	"	"	"	"	"	Boston "	17	per cent.
"	"	"	decrease	"	"	"	"	Baltimore "	7	per cent.

All the facts and considerations of the case lead me to the conclusion that the community must bestir itself if it would retain for its harbor the good name which is now associated with it. Let the cases of Marseilles and Glasgow, be a warning. Many years ago the Clyde became so foul that even poor trippers declined to board pleasure steamers nearer to the Broomielaw than Greenock several miles down the river. Since that time large sums of money have been spent on sewage disposal works, but the bad reputation justly associated with the name of the Glasgow harbor years ago will not be got rid of for many years to come. Every port has a duty to every other port, which if faithfully observed, would inaugurate a state of things that would go far to lessen the duties of port, sanitary and quarantine officers.

23 Discussion of the Metropolitan Sewerage Commission's Four Schemes for the Purification of the Harbor.

What then is the most practicable, the most hygienic and the most permanently economical scheme to adopt? I have studied the vari-

ous schemes put forward in the admirable reports which you have sent to the Mayor of the City since September, 1911.*

* Metropolitan Sewerage Commission's Preliminary Reports on the Disposal of New York's Sewage, I to V inclusive.

Although the schemes enumerated in your reports may not have exhausted every phase of what you term the art of sewage purification, yet in my view you have considered every method applicable to New York which can be regarded as reasonably practicable.

Scheme 1 refers to the application of sewage to land. (Broad irrigation and intermittent filtration.)

Scheme 2 refers to filtration of sewage through biological filters (bacteria beds).

Scheme 3 refers to treatment of sewage by a variety of methods at various points of outfall, each case being adapted to its special circumstances, and the ultimate disposal of partially purified liquid into the nearest water course.

Scheme 4 refers to the conveyance of a large part of the sewage out to the Atlantic ocean with the minimum of treatment.

Scheme 1.

Application of the Sewage to Land.

The popularity of irrigation as a means of purifying sewage is on the wane, chiefly owing to the extensive area required and the unsuitability of the land available.

The Berlin farm, which is the largest in Europe, continues to do good work. The largest farm in England was at Birmingham, but some years ago when land could no longer be obtained for less than three times its agricultural value, the authorities abandoned irrigation in favor of the intensive method of purification on bacteria beds. The largest farm in France is at Paris, and there also the authorities contemplate a change of method whenever it is necessary to increase the purification plant.

Where all the conditions are favorable, irrigation is undoubtedly successful as a vehicle of purification, and one which gener-
24 ally yields consistently good effluents, but in New York the farm would be so colossal in extent that the conditions would not be invariably favorable. The available land is, I fear, limited to Long Island, the area required would exceed 150 square miles. It would necessarily vary in its adaptability for the purpose, and although the standard of purification need not be exceptionally high in view of the large volume of water into which it would ultimately be discharged, it would still be necessary to limit the volume of sewage to 10,000 or 12,000 gallons per acre, unless a great expenditure for under drainage were undertaken.

Sanitary Objections.—A great area of land lying between Amityville and Quogue overlies one of the sources of the city's present water supply, and its use for sewage purification would be a potential source of plague which no one would care to risk.

The mere saturation of 150 square miles of land with sewage would be a menace to the inhabitants obliged to reside in the district, and would be sure to produce mal-odors during certain states of the atmosphere, which would be highly objectionable, even if they did not markedly influence the health statistics of the district.

I disapprove of this method of purifying New York sewage on grounds quite apart from cost; nevertheless, it is important to note that it is the most costly of the schemes brought forward, and would probably amount to $180,000,000; this, too, assumes that land could be acquired for about $500 per acre—a somewhat sanguine estimate.

Scheme 2.

Oxidation in Bacteria Beds.

The epoch-making experiments of the Massachusetts State Board of Health have led to the adoption of what has been called the intensive method of purification. By this, biological filters are made to take the place of land, and in your case would probably purify 140 times as much sewage as the same area of land under irrigation. It is a method which is almost invariably adopted in modern works which are located some distance from sea, lake or river.

To carry the whole or the major portion of the New York sewage to Barren Island and then treat it on bacterial filters would be costly, and could only be justified if it could be shown that a specially good effluent is essential at the point of discharge.

As the oyster beds will probably depreciate in value as the population of the district increases, it would not be wise on this account alone to incur the expense of this operation, more particularly as it is now admitted on all hands that the passage of sewage through a biological filter does not necessarily deprive it of pathogenic organisms, and in order to protect the oysters from the attack of a stray typhoid bacillus, it would in this case be necessary to sterilize before 1940 a quantity of sewage equal to about 700,000,000 gallons.

Danger of Nuisance.—Perhaps Barren Island is the very best site available for placing an installation of percolating filters, but it would appear as if Jamaica bay were on the eve of great developments, and that Barren Island would not for long be the isolated place it now is. I regard it as of the utmost importance to establish sewage purification works where they are not likely to become a nuisance, and I have grave doubts about the wisdom of placing so vast an area as 1,000 acres of bacteria beds so near to an industrial centre as they would be on Barren Island. In contemplating such a scheme there is a factor which should be taken into account, and that is the after effects of the evaporation of so much foul liquid as there must necessarily be from such an area of filters.

In 1911, when the summer weather in England was warmer than usual, there were complaints of smell nuisance at Henley, where the sewage is of about the same strength as the average American sewage, and where it is distributed over rectangular percolating beds by

mechanical distributors moving backwards and forwards. Complaints were also made by residents near the Birmingham works, where the sewage is sprayed over the beds by fixed nozzles.

The chief lesson to be learned from the 1911 experience is that an increase of flies is to be looked for in the neighborhood of bacteria beds in hot weather, and that objectional smell adjacent to them is more pronounced during prolonged hot weather than at other times, e. g., seasons like the average English summer, when the temperature rarely exceeds 65 Fahr. in the shade. But a much more serious drawback to a great area of bacteria beds during spells of prolonged hot weather is the formation of vaporous "clouds," due to the evaporation of sewage. These clouds appear to form over the beds in quiet weather. They rise to some distance above the earth, and at sundown, when the earth begins to cool, they return not alone as refreshing dew, but with offensive odor. If this occurred only in the vicinity of the bacteria beds, where the land is generally less valuable than at some distance, it would not be so serious in its consequences, but it generally occurs at some distance from the bacteria beds, the direction and distance depending upon the tendency and the velocity of the wind.

Cost.—Of course, it is only the mal-odorous element in sewage that makes this phenomenon noticeable; evaporation from clean water would act precisely in a similar manner, but it would manifest itself in welcome dew on the grass. This led me to adopt at Bir-
26 mingham the use of hypochlorite of calcium with excellent results, but the cost would be a serious matter where 700,000,000 gallons had to be treated each day; indeed, the bare probability of hypochlorite of either calcium or sodium (and the latter is even more effective) having to be used frequently, would be sufficient in itself to retard the adoption of a scheme which would be many times as large as anything now in existence. It is obvious that climate is of paramount importance.

The initial cost of 1,000 acres of biological filters to deal with 700,000,000 gallons of sewage, would be not less than $140,000,000, apart from maintenance charges. Altogether, I agree that the commission would not be justified in espousing this scheme as the best available for New York.

Scheme 3.

Local Treatment Works and Outfalls.

It is probably not far from the truth to say that the only purification of organic matter known to nature is an oxidising one, which is brought about indirectly by the agency of bacteria, but whether the vehicle by which the process is brought to fruition is the irrigation farm, the biological filter or dilution with large volumes of clean water, the "combustion" process is practically the same.

To protect the harbor from pollution, it is neither essential to confine the purifying process to one method, nor to one locality, but whether it is expedient or wise to construct dozens of sewage purifica-

tion plants in and around New York is an entirely different matter. Sewage from the various districts delineated on the plans could be sufficiently treated to admit of being discharged in the adjacent waters without creating a nuisance, but in some cases the treatment would have to be very circumscribed, and a greater burden would be placed upon the assimilating powers of the waters than they ought to be called upon to bear.

Essential Details.—It is unnecessary for me to refer in detail to the various outfalls that would be required under this scheme. Suffice it is to say that I have examined many of the suggested sites, with the invariable result that they all appear to me to have been chosen with great judgment and engineering skill. It is more than probable, however, that if Scheme 3 finds most favor, the sites shown on the plans, and referred to in your reports, may have to be altered when negotiations for the purchase of those sites are begun: this will be found to be specially true in the case of the nineteen outfalls on Manhattan Island.

Under this scheme it would be necessary to lay sewers towards an outfall which would terminate in the deepest water available in the vicinity, where it would be dispersed by a complete sy-
27 stem of moderate sized outlets so placed as to enter the stream transversely to the flow, and in sufficient number to encourage equal diffusion. Each outfall should be protected by grit chambers and settling basins in duplicate: the former should be provided with every appliance requisite to remove solids of large size, road grit, rags, etc.

Disposal of the Sludge.—The basins should be built so as to induce the sludge arrested by mechanical or chemical precipitation (as may be found best under circumstances which vary considerably at different outfalls) to collect at, say, the apex of an inverted cone or pyramid, and the sludge collected should be pumped daily into steamboats built for the purpose and removed well out to sea. This system of getting rid of sludge is well suited to a scheme which would have all its sludge tanks within easy reach of navigable water.

In my view the sludge should be removed daily so as to obviate smell nuisance. The only alternative would be to septicize the sludge in Emscher tanks, but this would mean large and deep tanks which would be incompatible with the conditions obtaining at some of the outfalls, particularly those in Manhattan, where the sludge tanks would perforce be placed in the streets abutting on the bulkhead and shore lines. The experience of the engineers at London, Glasgow and Manchester puts at rest any doubt as to the practicability of removing unseptic ized sludge by steamboat, but there is nothing equally convincing to show that if it were in a state of active fermentation it could be so easily removed and so quickly lost to view when dropped into the ocean.

Only Lin ited Treatment Practicable at Wards Island.—If such a scheme as this were to be car-ied out, its weakness would probably become apparent first at Wards Island, where 302,000,000 gallons

of sewage will have to be treated daily in 1940. The reasons I have given against the establishment of a great area of filter beds at Barren Island are even more potent when applied to Wards Island, so that either mechanical or chemical precipitation would in the present state of knowledge have to be resorted to, and neither process is efficient enough to warrant me in suggesting that such a volume of effluent could be discharged into the East river without unduly drawing upon the oxygen of the harbor water.

One of the leading factors in considering the Wards Island problem is the fact that the river, so called, is without a continuous flow of fresh water towards the sea; any sewage effluent, therefore, would have to rely upon admixture with the water of a tide in order to obtain the necessary supply of oxygen to obviate putrefaction, and considering the volume available for this purpose, I am doubtful whether the results would be acceptable at all seasons of the
28 year. Of course the sedimentation process including screening and sludge removal to sea, or that process plus the addition of a coagulant to help mechanical precipitation, do not exhaust the great sources of power in nature, and it is quite possible that we may before many years are over realize the practicability of electrolysed sea water. Your laboratory experiments stimulate me with hope, but I cannot in the present state of my knowledge recommend them as a practical solution of the problem.

Under this scheme there would be many outlets, all of which would require to be equipped with screens, grit chambers, tanks, and some kind of treatment works, before the effluent could be discharged and left for the nearest water to complete its purification by assimilation.

Scheme 4.

Conveyance of a Large Part of the Sewage to Sea.

The distinctive feature of this scheme is the provision of subterranean channels, or great sewers, into which each part of the municipality embraced within a prescribed area would have the indisputable right to discharge sewage and trades wastes without let or hindrance, knowing that the sewage would be conveyed right out to the Atlantic ocean. Nothing in the nature of treatment beyond arresting solids that would otherwise obstruct the pumps would be undertaken en route.

One important feature of this scheme would be the formation of an island in the sea about three miles south of Coney Island. The formation of such an island is by no means unprecedented, but the idea of forming one some miles from land for the sole purpose of treating sewage is a novelty in the history of sewage purification.

Scheme 4 involves pumping the sewage, screening it, arresting a proportion of the suspended solids in sedimentation tanks to be constructed on the island, and thereafter leading it by a series of pipes into deep water to secure effectual diffusion.

Having the sewage tanks on the island would obviate the usual troublesome claims for compensation in respect of depreciation of

value of adjacent property. The island could be extended almost indefinitely as occasion for extension arose. Its position would be the best possible from which the superintendent of the works might observe the ebb and flow of the tide, and regulate the emptying of the sedimentation tanks.

29 The Treatment Necessary.—The question of the extent to which sedimentation should be carried is one which will gradually settle itself. I do not think it will be necessary to effect settlement until after the first section of the work has been in operation for some time, but as section after section is completed it will be found necessary to arrest the solids in tanks, made with the view of concentrating the sludge at the bottom of either conical or pyramidal pockets placed at an elevation to induce the sludge to flow by gravitation.

The precise site of the proposed island will require careful consideration, but that shown on your plan appears to be feasible. Excepting rip-rap for the external formation, nearly all the material for making it can be readily and cheaply obtained chiefly from (1) debris or spoil from building sites which at present is dumped into the ocean; (2) spoils from the tunnels and terminating shaft, and (3) sand pumped from the adjacent sand banks.

The Progressive Steps in this Scheme.—The first step to be taken if this scheme is entertained is to collect sewage from those parts of Manhattan and Brooklyn which border on the East river, convey it by tunnel to a central pumping station at Wallabout, near the Navy Yard, and lift it to another pumping station at Sheepshead bay, whence it would be conveyed to the projected island for disposal.

The population of the districts to be served at first by this instalment, and the dry weather flow of sewage pertaining thereto, are as follows:

District.	Population, 1915.	Sewage, Gallons per day.
Manhattan	680,000	99,000,000
Brooklyn	732,000	104,000,000
Total	1,412,000	203,000,000

The Wallabout pumping station would lift 133,000,000 gallons coming from the north, 18 feet in height, and 70,000,000 gallons from the south, 33 feet in height, and the Sheepshead bay station 203,000,000 gallons about 38 feet in height.

This instalment could be executed for about $18,000,000, which would entail for interest (at 4½% for 50 years) together with maintenance charges, an annual payment of $1,500,000, but I do not recommend you to limit the size of the tunnel to a carrying ca-

30 pacity of 400,000,000 gallons, or about twice the dry weather flow, as I believe the second instalment of the scheme should be undertaken soon after the completion of the first.

The second instalment, I apprehend, would be to couple up the intercepting sewer which would serve the Jamaica Bay Division, shown on the plan accompanying your report to the Mayor, dated November, 1911.

The third instalment of the work should bring the sewage of the Upper East river and Harlem Division into the system, and the fourth would take in Richmond and as much of New Jersey as may be determined.

In my opinion all the intercepting sewers should be capable of conveying not less than twice the dry weather flow before storm water is shed into the nearest watercourse; this would correspond favorably with the English practice of conveying six times the dry weather flow,* or rather less than 200 gallons per head per day.

Need of a Permanent Sewage Disposal Commission.

Of the four projects thus briefly outlined as possible schemes for adoption, I have a decided preference for Scheme 4. I admit that Scheme 3 is feasible, but it lacks finality and possesses features which should be avoided when possible, e. g. the numerous outfalls and the drawbacks attaching to them in the eyes of the general public, their not invariably suitable locations, and their inevitable increase in number as the population increases. What influences me most in favor of Scheme 4 is the conviction that where it is possible to remove the bulk of the sewage of New York entirely away from its source to the ocean it should be so removed, although the cost may be somewhat higher than it would be under a project like Scheme 3.

In a great city where such public services as water supply, sewerage and sewage disposal are indispensable, and where several self-governing municipalities benefit by the common service, it is essential in the interests of good and economical administration that there should be a permanent commission, with jurisdiction over the whole area. Such a general commission from its very constitution is enabled to deal with questions more comprehensively than local boards, commissions, departments or bureaus can do. Probably an example of what I mean may be found by reference to the endeavor to improve the insanitary conditions of the Gowanus canal, where a local sewer bureau tried to remedy a nuisance by conveying a stagnant,
31 putrid liquid from one locality to another in the same neighborhood. No doubt the bureau did the only thing available to them at the time, but they were obviously restricted in their outlook, and were forced by circumstances to mitigate rather than remedy the evil, whereas if it had been possible for them to order the polluted waters of the canal to be conveyed beyond the municipal boundaries to the ocean, the evil would have been effectively remedied. A municipal engineer's work is often unfairly criticised because the effects of being hemmed in by surrounding boroughs is not adequately appreciated. Administrative questions, like sewerage, are not invariably united, but here they should be under one commission or board, and it is with the object of devising a workable scheme for keeping the harbor free from solid as well as liquid impurities that I suggest the formation of a commission to be entrusted with the duty

* For comparison between English and American sewage, See Preliminary Report VI, of the Metropolitan Sewerage Commission of New York, January, 1913.

of making and keeping pure (or reasonably pure) the national waters.

Proper Functions of a Permanent Commission.—The constitution of such a commission would have to be carefully framed by those who are well versed in existing statutes and inter-state law, but I venture to suggest one or two points which should be carefully embodied in the constitution.

The whole responsibility for maintaining clean waters within the prescribed area should rest upon the commission, and they should have all necessary power to enforce their regulations.

The commission should be responsible for the design of all intercepting sewers, pumping stations, tanks, outfalls, &c., essential for the construction of a complete installation of sewerage and sewage disposal works. The board should also be made responsible for the construction of these works, and for their subsequent maintenance.

Each borough or municipality must have the same right to connect to an intercepting sewer or sewers that they now have to discharge sewage into harbor, river or watercourse.

The commission should be charged with the duty of seeing that pollution, which must be inevitable until the intercepting sewers or subterranean tunnels are all built and connected to the ocean outfall, does not increase, even although it should be necessary to construct temporary works for the purpose.

The joint board or commission should have ample power to decide whether an intercepting sewer or any other work is required, and to allocate the cost of construction to the users. It should also have power to regulate by bye-laws, or otherwise, everything which pertains to the keeping clean of the harbors, rivers, canals or watercourses within the area for which it is responsible. If it is
32 usual to give such commissions rating, borrowing or financial powers, the board should be so empowered.

In recommending the adoption of Scheme 4 it is not to be assumed that I advocate its complete execution at once. If I have succeeded in presenting the whole project correctly, it will be apparent to all that the dominating factor is and must continue to be the condition of what I have called the national waters. As it stands at present, the putrefactive liquid entering them increases daily; their power of oxidising foul liquid is practically stationary, and as every sewer is diverted to the Atlantic ocean by being coupled up to the system under scheme 4, their condition will improve. I do, however, advocate progressive, consistent advancement until the completion of the scheme be attained, which I hope will be not later than 1925.

Necessity for Immediate Action.

I cannot say too distinctly that there is need for immediate action. The nature and extent of the tunnel work bars haste and precludes all chance of redeeming lost opportunities; therefore no opportunities should be lost.

Generally, I am in sympathy with the plans you have prepared; particularly do I espouse what you call Project I as the first step to

be taken. There should however be a comprehensive plan matured if possible in conjunction with the engineers of the several sewer bureaus, which will indicate how every link of the complete scheme will be caught up in regular progressive stages. This is the more important as there might be more or less prolonged intervals between each successive stage.

It will probably cost not less than $100,000,000 to complete Scheme 4, undoubtedly the largest sum ever contemplated for such a purpose, but no scheme has hitherto been designed for the service of 12,000,000 people. Many small towns have spent more per capita than this estimate implies, and frequently all they gained was the removal of a liquid which possessed potential elements of plague. The citizens by approving the conveyance of all the sewage to the Atlantic will gain that and more, for they will at once purify their harbor and rivers, which never will cease to be the most priceless and most striking physical characteristic of New York.

Comparison with European Undertakings.—If one were to attempt a comparison between the cost of the sewerage systems of European capitals, and what is now proposed for New York, the great disparity between the quantities of potable water used by the inhabitants of cities of the Eastern and Western Hemispheres
33 would arrest attention. The world has been startled by the magnitude of your water schemes. Any European city would have regarded 114 gallons per capita as an extravagent allowance, yet this—which is equal to a daily supply of 500,000,000 gallons—is what is now obtained from the Croton works alone, but rather than curtail that supply, or do anything which might be interpreted to favor a limited use of water for public health purposes, the authorities determined to carry out a gigantic scheme to obtain another 500,000,000 gallons of water per day, this time from the Catskill mountains. The magnitude of the undertaking, and the aggregate cost of bringing in 1,000,000,000 gallons per day will place the New York water supply in a category by itself when a history of the world's great water works comes to be written.

The consumption of water has a direct relationship to a city's sewerage system as regards cost, and it is incumbent upon an engineer in recommending a scheme to satisfy himself that it is not only sound as an engineering proposition, but that it is financially possible. The facts I have brought to your recollection go a long way to show that a scheme of sewage disposal which will ultimately cost $100,000,000 and involve an annual outlay of $5,000,000 for the benefit of 12,000,000 people is not disproportionate to the requirements of the city. But I have not relied alone upon the example of the water works in coming to this decision. The numerous public schools, seats of learning, public institutions, colossal buildings, wide streets, stupendous bridges of unparalleled width, not to speak of railroad, canal and private enterprise, the most recent examples of which may be found in the Pennsylvania and Grand Central stations, which between them have cost not less than $300,000,000, all direct one's attention to indisputable evidence of prosperity and progress, and to what is of even more importance, the attitude of mind which

shows that the people have a profound faith in the future greatness of their marvellous city.

It is quite unnecessary to caution you that all estimates of cost, so far as they have been prepared by me, must be regarded as of a tentative character, and should be accepted cautiously until complete surveys, detailed plans and sections are made, and schedules of quantities drawn up—nevertheless they seem to me to be quite ample for the work contemplated.

I am, gentlemen, your obedient servant,

JOHN D. WATSON.

Birmingham, 31st January, 1913.

a COMPLAINANTS' EXHIBIT No. 204. James D. Mabee, Commissioner.

Report of Observations of Sewage Disposal Works in Hamburg, Dresden, and Frankfurt, Germany, by Samuel A. Greeley, Sanitary Engineer, September, 1911.

1 **Hamburg.**

August 30th and 31st—September 1st.

Description.—Hamburg is a city of about one million inhabitants in Germany, on the River Elbe. The river divides the town into a larger northern section of about 850,000 people, and a smaller southern section of about 150,000 people. Near the center of the northern district is a large lake or basin, called the Alster; and there are several small streams and canals throughout the city. The southern section is chiefly a manufacturing and shipping center, and is all cut up with slips, harbors and docks. The city is a large shipping center and there is a continuous passage of ships of all kinds back and forth on the river. The whole city is sewered on the combined system, and there are numerous overflows for storm water at various points throughout the city, on the Alster and the smaller streams and canals. These overflows are arranged so that no discharge takes place directly into the water courses until the normal dry weather flow has been diluted with rain water in the proportions indicated in the following table for the various classes of water courses:

Volumes of Dry-weather Flow and Rain Water in the Combined Sewage at Time of Overflow.

Kind of water course.	Volume of dry weather flow.	Volume of rain water.
Elbe River	1	1
Lower Alster	1	3-1/2
Upper Alster	1	5
Small streams & canals	1	10

2 This information was given to me by Herr Brunotte, engineer in charge of sewage disposal. Previous to the time of my visit and while I was in Hamburg, these storm overflows had not been used for at least six or seven weeks.

The sewage of the northern district is all conducted to one main point of discharge into the Elbe river. The sewers leading to this point of discharge are large, smoothly built, well ventilated, and have good slopes, so that the sewage reaches the point of discharge in a fresh condition, without much odor. Herr Brunotte told me that the minimum velocity of flow in the system was 0.6 meters (1.97 ft.) per second, but that this minimum was confined to a few small

sewers and that in the main trunk sewers the velocity of flow was about 1.0 meters (3.28 ft.) per second. He estimated that the time of flow for most of the sewage coming to the northern district point of discharge was from two to four hours, depending upon the volume of sewage flowing in the sewers.

The sewage from the southern district will eventually be concentrated at one point of discharge. At the present time, the sewage from only about one-third of the population of this district is so concentrated, the remainder flowing directly into the Elbe through various slips and canals.

With regard to the preliminary treatment of trades wastes, there are certain rules, which Herr Brunotte summarized as follows:

(1) Factories must first neutralize their waste liquors.

(2) Oil, fat, etc., must be held back by a scum board.

(3) Asbestos works and some other special works must have settling basins.

3 Herr Brunotte told me that these rules were not enforced to affect over 25% of the trades waste; and in talking with Herr Helmke (an assistant engineer who went to the disposal works with me), I gathered that this statement was rather optimistic than otherwise.

The Elbe river, as it flows through Hamburg, is a tidal stream. (See accompanying tables of high and low tide at Hamburg, Appendix H.) the water being yellow-colored and turbid, with a fine "mucky" sort of suspended matter. Above the town it is used for the city water supply and is not strongly colored or turbid, but requires filtration to make it a clear, safe drinking water. The intensity of the tide is about 3 meters (9.8 ft.), but the stage of the water at Hamburg varies with the wind, being highest after a long continued west wind which piles the water up stream. I asked everywhere for some data relative to the Elbe watershed above Hamburg, but could find none. Herr Brunotte quoted to me the average flow of the Elbe at Hamburg as being 1125 cbm. per second (25,677,324,000 gal. per 24 hrs.), with a minimum of 150 cbm. per second (3,423,643,200 gal. per 24 hrs.), to be expected once every twenty or thirty years. Herr Brunotte's authority for this statement was a book entitled

"Hamburg in Naturwissenschaftlicher und Medizinischer Beziehung."

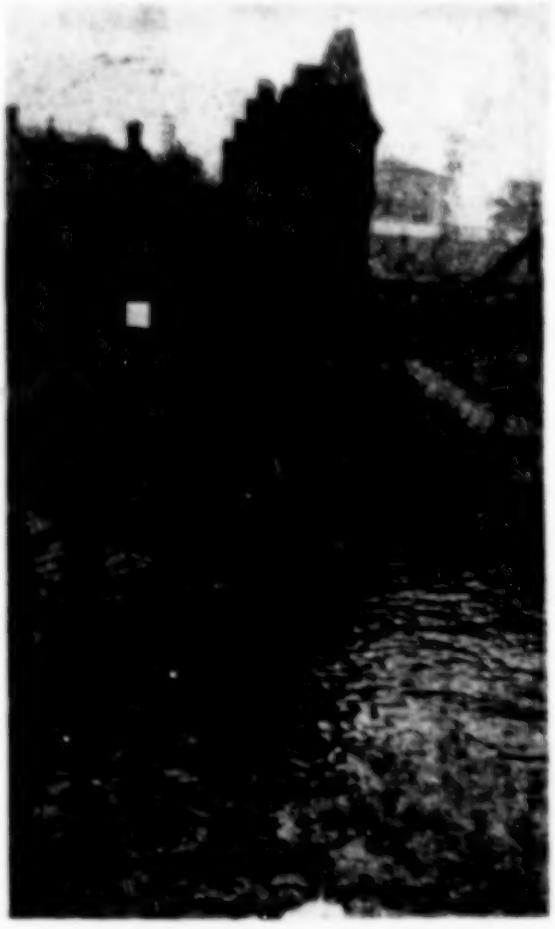
(Sonder-Abdruck.)

Hamburg.

Verlag von Leopold Voss.

1901.

4 This can be purchased from Boysen and Marsch, Heuberg, Hamburg, for 15 marks ($3.75).



Nº 1.

Hamburg screening plant,
Northern district.

Tower through which sludge and screenings are discharged into the tank boats. Tank boats shown below.

(Exhibit No 204)



Photograph of sea-gulls over outlet of the Hamburg screening plant (northern district). Note the density of the buildings.

Nº 2

At the time of my visit, the quantity of water flowing in the Elbe must have been very low, because this summer has been one of the driest in Germany for many years. I was unable to secure accurate data on this point, but was told that by writing to the Strom and Hafen Bau Abteilung, Dahlman Str., Hamburg, in an official way, the data could be secured. However, I found at Dresden that the Elbe was at its lowest stage this summer, and throughout my travels everyone spoke of the extreme drought in Germany. Herr Brunotte stated that the filtered Elbe water was not unusually hard and was used for many boilers without preliminary treatment. The immense number of ships and tugs passing continuously back and forth on the Elbe keep the surface water churned up so that it is always choppy and there is little opportunity to observe sleek on the surface.

The Disposal Works.—Both northern and southern districts are equipped with disposal works. These consist of (1) coarse bar screens at the end of the main sewer; (2) small grit chambers, and (3) revolving mechanical screens of the belt type.

The old plant, serving the northern district, is located on the river front in a very busy, thickly built up section of the city. The environment is undoubtedly critical. (See photographs Nos. 1 and 2.) Within about four blocks is the seaman's school and the entrance to the new tunnel under the river. (See map of Hamburg, marked Appendix IV.)

(Here follow photos marked Nos. 1 and 2.)

5 This plant has one grit chamber, containing two screens. The bars of these screens are spaced 15 millimeters (0.59 inches) in the clear, and the screens are each 3.3 meters (10.8 ft.) wide. The screens travel at the rate of about 2 meters (6.56 ft.) per minute, and have only one speed of operation. They operate only at low tide because at high tide the river water is higher than the sewer water. There is a period of from 1 to 5 hours, averaging over 1 hour, when there is no discharge and the sewage is allowed to back up into the sewers. The river is highest when a heavy west wind drives the sea water up stream, and this reaches a maximum when it is combined with a heavy rain. Under these conditions, which I was told happened during the spring of 1911, the period of discharge lasts only for about one hour. (See descriptive illustrated pamphlets of Hamburg's sewers and screening plants—marked Appendix III A and B.)

The average quantity of sewage flowing through this plant is 190,000 cbm. (50,192,300 gals.) per 24 hours. It flows through the grit chamber at a velocity varying from 0.8 (2.62 ft.) to 1.2 meters (3.94 ft.) per second.

The grit chamber is cleaned two or three times a week, the cleanings amounting to from 12 (15.7 cu. yds.) to 16 cbms. (20.9 cu. yds.) daily. The screens, which are cleaned continuously during operation, remove from 10 (13.0 cu. yds.) to 50 cbms. (65.4 cu. yds.) daily, the average removal being 20 cbms (26.1 cu. yds.) per day of wet screenings. The sludge and screenings are dumped into covered steel barges which are towed to the dumping grounds, several miles below the city.

6 After the sewage passes through the screens, there are five discharge pipes through which it may pass into the river. Ordinarily only three of these are used, the other two, which extend only to the water's edge, being used during times of storm flow only. The other three pipes extend into the river 70 meters (229.6 ft.), 100 meters (328.0 ft.) and 133 meters (436.2 ft.) from shore respectively, and all are turned up 90° at the end and discharge at the bottom of the river.

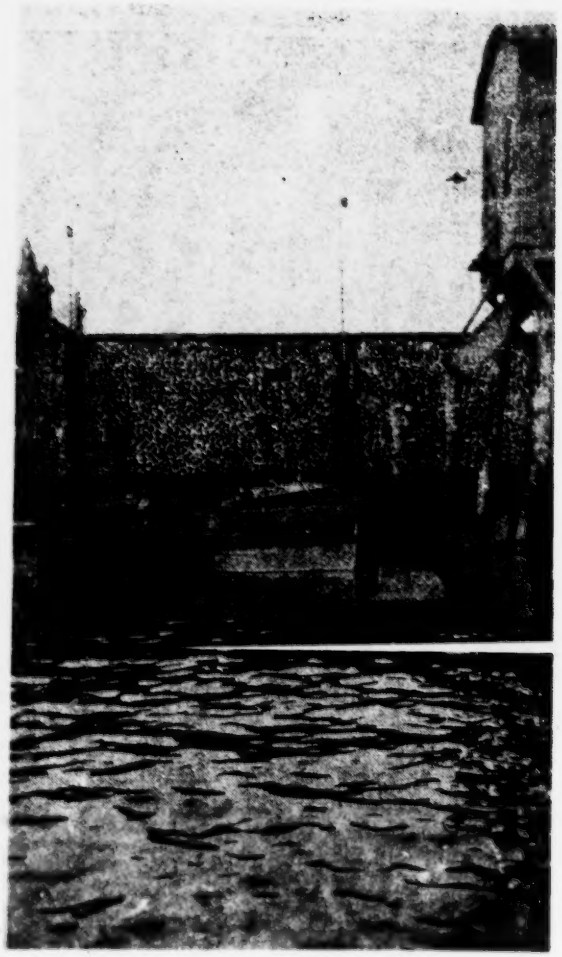
The new plant is located at the end of the Kaiser Wilhelmshafen, and is attractively built of red brick, with well kept up grounds. It is in the heart of a busy shipping neighborhood, in the close proximity of many commercial buildings. (See map of Hamburg, marked Appendix IV.)

The plant consists of two grit chambers, each fitted with two screens; and there are pumps to lift the screened sewage into the river. At the present time the pumps are not connected, and the effluent from the works discharges about midway between high and low tide and at the shore just south of the Reiherstrasse Bruecke.

The grit chamber and screens are very similar to those at the old plant. The important differences are, (1) that the bars of the screen are spaced only 10 millimeters (0.39 inches) in the clear; (2) that the velocity of the sewage striking the screens is less, and (3) that the screens travel more slowly.

The plant is operating below capacity, only about 6,000 cbms.

(Exhibit No. 204)



No. 3.

Hamburg Screening Plant, Southern District,

Sludge Tower and Tank Boats.

(Exhibit No 204)



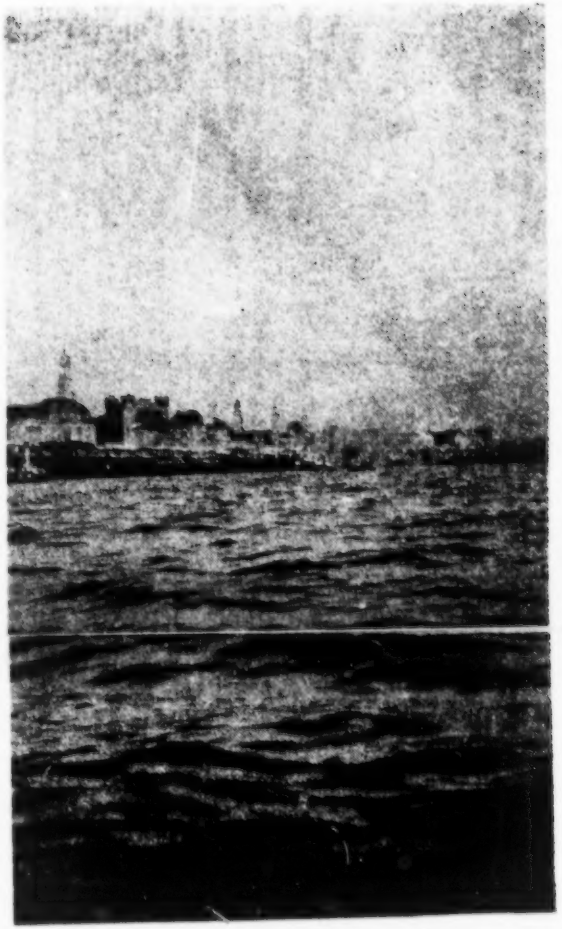
No. 4.

Hamburg Screening Plant,

Southern District;

Discharge of Effluent.

(Exhibit No 204)



No. 5.

Hamburg Screening Plant,

Northern District,

Approaching the old plant.

Note gulls over the water.

(1,585,020 gals.) daily of sewage being handled. The grit
7 chamber is cleaned once a week, when about 60 cbms. (78.5 cu. yds.) of sludge are removed.

Work done—Aug. 30.—In the morning I called on Herr Brunotte and talked with him about a half-hour. I returned to Herr Brunotte's office at 1:30 P. M. and met Ing. Helmke, who took me to the new plant and from there by boat to the old plant. This trip took the whole afternoon.

Aug. 31.—About 9:30 A. M. I reached the old plant, to observe the conditions while there was no discharge of sewage. Then I went in a launch down the river, to see where the sludge was handled and, coming back, took samples of Elbe water for observation. This took all day.

Sept. 1.—In the morning I called on Herr Brunotte again and talked with him for about one hour. Later I called on Ing. Heinrich Luhr, who is now in the water bureau, and questioned him with reference to the water supply.

General conditions during visit.—The summer of 1911 in Germany has been a very dry one, one of the driest in twenty or thirty years. Previous to my visit, it had not rained for six or seven weeks, and during my visit there were only one or two short, light showers, that left no apparent effect on the pavements and affected the sewage flow but little. For the rest, the weather was clear, with a fresh breeze blowing most of the time.

8 Visits made Aug. 30.—Ing. Helmke and I left Herr Brunotte's office about 1:30 P. M. and proceeded by trolley, ferry and on foot to the new screening plant on the south side of the Elbe. The general appearance of the plant, as we approached it, was attractive and no sewage odor was noticeable until we had entered the grounds. They were trying out some sprinkling filters which smelled a little, but the strongest odor noticeable was from the tower used to discharge the sludge and screenings into the tank boat. (See photograph No. 3.) We passed this on our way to the pump house and screen room. It could not have been called objectionable, but the wind was blowing the odor away from me.

(Here follow photos marked No. 3, No. 4 and No. 5, pages 9 and 10.)

11 Inside the screen house there were evidences that the plant was not having sufficient sewage delivered to it. The screens were not operating and the sewage was flowing through very listlessly. The sewage was black and greasy in appearance and there was evidently much oil in it. They started the screens for me and also lifted a bucket full of sludge for me. This action liberated a lot of gas bubbles in the sludge, and they bubbled up through the heavy liquid but did not smell strongly. After observing the screens and grit chamber, we went to the tower through which the screenings and sludge are shot into the tank boat about 20 feet below. This tower was not very well cleaned and when I stepped into it, I could get the strong pig-pen odor easily, though the wind was blowing briskly.

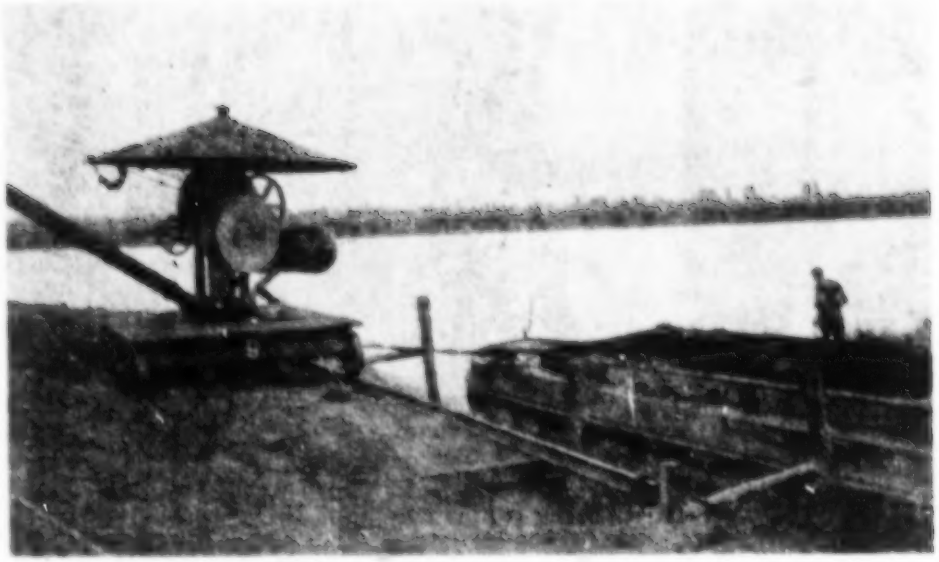
We then took the city launch and went to the outfall of the effluent from this plant. This is shown in the accompanying photograph No. 4. This was about a 30 inch sewer, discharging at the shore and about 5 feet above the water level at the time of my visit. There was a barge anchored directly below this outlet and some carpenters were doing some repair work on the barge. There was no serious nuisance at this outlet. The sewer was only flowing about 3 inches full.

From here we went by the city launch to the old plant, and on the way there was good opportunity to observe the Elbe water. (See photograph No. 4.) This was in all places a yellowish brown, without many large floating matters. The river was very choppy (and they say always is), so that there was very little opportunity for sleek to collect on the surface. Here and there, I saw a few blotches of it, say about 12 inches in diameter. As we came within

12 100 yards of the plant, there was a slightly noticeable sewage odor (I found out afterwards that this probably came from the sludge boat).

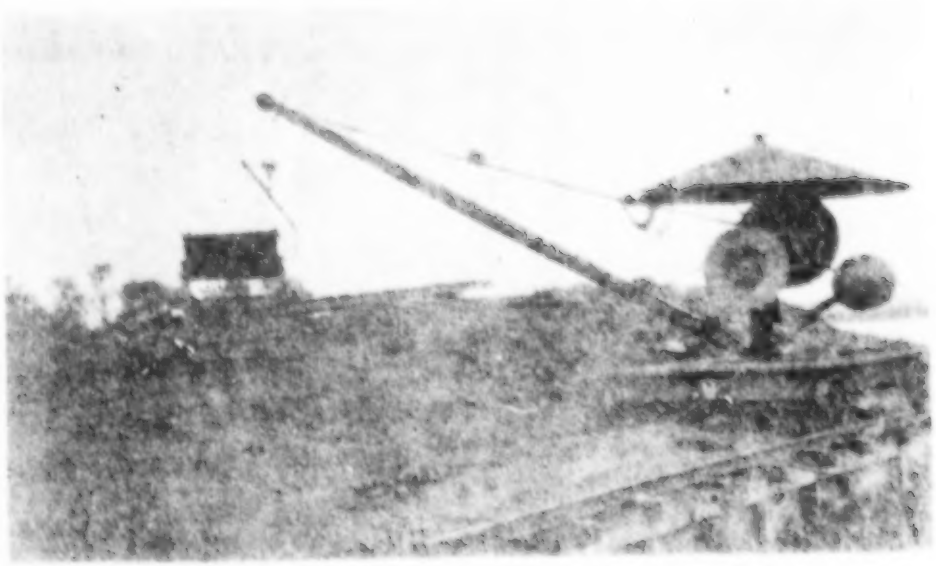
The buildings and grounds of this plant were also attractive. Entering the screen room there was, of course, a sewage odor, but this was not noticeable outside the plant. The sewage appeared fresh (fresher than at the south district plant) and did not smell strongly. The depth of sewage in the grit chamber, I measured to be 3 meters (9.8 ft.). It was flowing through at a good velocity (much faster than at the new plant). I timed the screens to be traveling at about the rate of 30 cm. (11.8 inches) in 8 seconds. After this we went to the tower through which the screenings are discharged into the barge. Here again was the strong pig-pen odor.

After visiting the plant, we went in the city launch to just over the outlets. Ing. Helmke pointed out the general location to me by some small floating matters and a white foam or froth on the water surface. There were sea-gulls flying about this part of the river, although I had seen them nowhere else. On the day of my visit, it was cool and there was a good breeze blowing from just west of north. The river was very choppy. I could not see any marked evidences that sewage was being discharged into the river, except the gulls. That is, the water was not discolored and there was no marked sewage odor from the river water at the outlets.



(Exhibit No. 204)

No. 6.
Hamburg Screening Plants
Tank Boat at Point of Disposal of Screenings.



(Exhibit No 204)

No. 7.
Hamburg Screening Plants
Derrick and Dump for Sludge and Screenings.

The only strong odor came from the sludge and screenings. The evidences of sewage discharge were the slight clusters of white froth and the few floating particles.

13 Visits made Aug. 31.—I went first to the old plant, arriving there about 9:50 A. M. The outlet gates were closed and the sewage was standing in the grit chamber. I was told that this had been so for about half-an-hour. The depth of sewage on the fixed gauge was 4.57 meters (14.9 ft.) or 1.57 meters (5.1 ft.) higher than yesterday afternoon.

The day engineer at the plant told me this morning that, during stormy weather, the gulls flocked thickly over the sewer outlets.

The sewage in the grit chamber was bubbling somewhat, but the odor was not objectionable. The temperature of the sewage in front of the screens was 20.5° C. (68.9° F.).

At 10:10 I took a launch with an English speaking engineer and went to Newenfelde, where the screenings from the plants are disposed of.

(Here follow photos marked Nos. 6 and 7, page 14.)

15 We reached Newenfelde about noon and had a two mile walk to the small unloading station where the tank boats from the sewage plants are unloaded. The country we walked through was wholly devoted to truck gardens and orchards, and the whole neighborhood smelled of the pig-pen odor from the sewage screenings used as fertilizer. We saw it lying on the fields.

The unloading station is located on a small creek and was very foul. It consists of only an inlet for docking the tank boat, a derrick, some trucks and a narrow-gauge, movable track. (See photographs Nos. 6, 7 and 8.) The derrick is used to lift the body of the truck from the frame to the boat. There it is filled with a shovel and then replaced on its frame, and the whole car is then run out onto the dump. This dump was about 5 feet deep and 75 ft. by 50 ft. in area, and was very foul. The farmers come and cart this material away, paying 1 M. and 20 pf. per cbm. (22.3 cents per cu. yd.).

Coming back in the launch, I took especial notice of the well-kept beaches along the Elbe, where there were sailing boats and small row boats for hire. Here and there were bathing places. These were located within two miles of the sewer outlet and down stream. (See map and photograph No. 9.) The shore below the outlet did not show evidences of serious pollution.

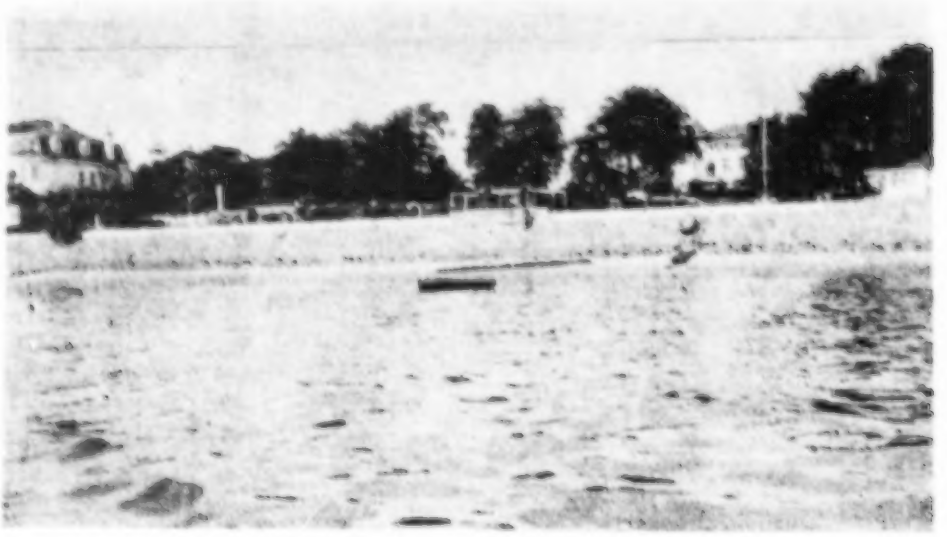
On the way back, I took samples of the Elbe water at approximately the points marked on the map. The samples were taken by dipping the bottle, on the end of a string, into the river and taking the first bottle full as a sample. I took the temperature at points marked (1) and (4) and in both instances it was 19° C. (66.2° F.).

Here follow photos marked Nos. 8, 9 and 10, pages 16 and 17.)



(Exhibit No 204)

No. 8.
Hamburg Screening Plants
Farm wagon carting away sludge and screenings from dump.



(Exhibit No 204)

No. 9.
Bathing Beach about three miles
below Hamburg sewage outlet (old plant)

18 As we returned, there were gulls flying over the outlet. I photographed these, as shown.

Description of samples of Elbe water.—On the trip back on the launch, I took six samples of Elbe water at the points marked on the accompanying map. The samples were taken about six inches below the surface, and were secured by dipping the bottle on the end of a string, the first bottle full being taken. These six samples I took back to my room and photographed them, as shown on the accompanying photograph No. 10.

All the samples were colored a yellowish brown, which did not increase on standing twenty-four hours. In each of them there was a fine "mucky" sediment. I tried the relative turbidity of the samples by the clearness with which I could see the lines of a sheet of paper (similar to the attached sheet) when looking vertically through the water. The bottles were about 5 inches deep.

Bottle No. 2 showed the greatest turbidity. The lines of the paper were just visible when observed near a window one hour before sunset, with no direct sunlight, on, a perfectly clear day. Samples Nos. 1, 4 and 5 were next in degree of turbidity. Then came No. 6, with No. 3 the clearest. There was very little to choose between Nos. 1, 3, 4, 5 and 6, No. 2 being distinctly darker than the others.

All the samples had a slight salty, fishy odor, which did not increase perceptibly after twenty-four hours. There was a fine sediment in the bottom of each bottle, and there was much
19 finely divided suspended matter throughout the water. The yellow color was the greatest mark.

The accompanying photograph (No. 10) shows the six bottles with a glass of clear water in the center. Sample No. 2 is the second bottle from the right of the picture.

I was unable to obtain any analyses or observations of the microorganisms in the Elbe water. However, I secured a book entitled as follows:

Hamburgische Elbe-Untersuchung.

I.

Allgemeines über Die Biologischen Verhaltnisse der Elbe bei Hamburg und über die Einwirkung der Sielwässer auf die Organism des Stromes.

Von Richard Volk.

1903.

This book gives data on both the chemical and biological contents of the river water. It is attached as Appendix V.

Summary of Observations.—1. That the discharge of the effluent from the sewage screening plants of Hamburg into the Elbe did not add seriously to the turbid appearance of the water, the Elbe itself being a colored turbid water at that point.

20 2. That the absence of a discernable sewage field was due to the dispersing of the sewage in the water through the agency of the ships, tugs and tides which intersect the water at many angles and keep the water continuously churned up.

3. That there were evidences of sewage pollution, such as the presence of gulls, the sleek near the docks and the floating particles.

4. That the greatest nuisance from the plants came from the handling of the sludge and screenings at the plant and from their ultimate disposal on land.

21 *Dresden.*

September 2nd.

Description.—Dresden is a city of about 550,000 people, situated on the River Elbe in the central eastern section of Germany. The river divides the city into a larger southern district called "The Old Town" and a smaller northern district called "The New Town." There are no other important streams or canals flowing through the town, and the sewage from both districts flows to one main disposal station below the city and then into the Elbe. At this disposal station, the sewage is screened before entering the river.

Unlike Hamburg, Dresden is not a great shipping center, but has what one might call "an average" population. That is, there is no great preponderance of any one class of population. The trades wastes do not form as important a part of the sewage as at Hamburg.

The Elbe river, as it flows through Dresden, is a fresh water stream, dark in appearance, with a velocity (as I observed it) of less than four miles an hour. At the time of my visit, the surface was smooth and there was some sleek evident on the surface near the shore even above the sewer outlet. The river is not used greatly for shipping, but there are a good many small river steamers and barges anchored along the bank (during my visit the water was too low for many of them). There are several bathing houses along the river, showing that the water is used for bathing, but the water supply for the town is taken from springs and wells, and not from the river.

(See map, Appendix VI.)

22 The quantity of water flowing in the Elbe and the quantity of sewage reaching the disposal works were given to me by Dr. Neidner, with whom I talked at the city hall, as follows:

Elbe:

Minimum flow—50 cbms. per sec. (1,141,214,800 gal. per day).

Normal flow—100-300 cbms. per sec. (2,282,428,800—6,847,268,400 gal. per day).

Maximum flow—6,000 cbms. per sec. (136,945,728,000 gal. per day).

Dry-weather sewage:

A daily average flow of 100,000 cbms. (26,417,000 gal.)

A daily variation of from 500 to 2,000 litres per sec. (11,412,144 to 45,648,576 gal. per day), the maximum occurring between 11 A. M. and 14 P. M.

Storm sewage:

A maximum of 18,000 litres per sec. (410,837,184 gal. per day). This exceeds the capacity of the four screens and part of the flow is by-passed directly into the river.

During my visit the river water was flowing at the minimum rate of 50 cbms. per second (1,141,214,800 gal. per day) and the sewage was about 1/25 of the river water. These are extreme conditions.

Dresden is sewered on the combined plan. There are two main intercepting sewers—one on each side of the river. These flow down stream with an approximate slope of 1 to 3000, and the flow in them is rapid. The superintendent at the screening plant (who speaks English quite easily) told me that the time of flow of sewage from the center of town to the disposal plant was only about one-half hour, and the time of flow for most of the sewage did not exceed 2¼ hours from the point of entrance into the answer to the disposal plant.

23 The disposal plant, where the sewage is screened, is located well below the town in open country, on a large tract of farm land owned by the city. It is located on the north side of the Elbe. The sewage from the southern district passes under the Elbe in a siphon near the west end of the city. Just in front of this siphon is a grit chamber. The sewage from the north district comes direct to the plant, but passes through a grit chamber just before reaching the disposal plant.

The Disposal Works.—The two main sewers, after passing through the two grit chambers, come together near the disposal works, where the sewage is treated before flowing into the river. (See descriptive pamphlet, marked Appendix VII.)

The disposal works consist of

1. An office building.
2. A house in which are located coarse bar screens and scum boards.
3. A main screen house in which are located four of the large disc type screens.
4. A pumping station.
5. A house for the workmen.
6. By-pass conduits for the rain water.

The buildings housing the apparatus, offices, etc., are all large and attractive. The rooms are high, the areas are ample and the yards are large and well paved. The city owns a large tract of land about the works, but does not now use it for farming purposes.

24 There are no buildings within half a mile of the plant, and the location is not at all critical.

It should be stated that, except the two grit chambers, there is no opportunity for sedimentation of the sewage at the plant. The velocity of the sewage flowing through the works is rapid, so that few deposits are made.

In the preliminary screen house the coarse bar screens are arranged in duplicate, each side having three tiers or sets of screens. The spacing of these screens, beginning at the bottom, is approximately 2″, 4″ and 6″ respectively. They all slope at about 60° with the horizontal, and each tier is provided with an accessible platfrom from which a workman rakes the screen clean. It is sometimes necessary to clean these screens once every thirty minutes. But generally once every four hours is sufficient.

The main revolving, mechanically cleaned screens are of the "Riensch" disc type and are 8 meters (26.24 ft.) in diameter. They are described in the accompanying pamphlet. As shown, these screens are revolving discs of perforated brass plates, fitting around the lower circumference of a truncated cone of brass plates. Each of these screens has a total open area of 14 sq. meters (16.74 sq. yds.). They revolve at two speeds, e. g.—1 revolution per 2 minutes and 1 revolution per 3 minutes. They are run generally at the lower speed. The slits through which the sewage passes are 2 mm. (.078 inches) wide on top, 3 mm. (.117 inches) wide on the bottom and 30 mm. (1.17 inches) long. The brass plates are 5 mm. (.196 inches) thick on the disc and 4 mm. (.157 inches) on the cone.

25 Each screen has a normal capacity of 650 gallons per second (56,160,000 gal. per day), and in dry weather one screen handles the whole flow. Maximum flow requires the operation of all of the four screens.

The maximum loss of head in going through a screen is 60 cm. (23.6 inches), and when this is reached, either the speed of the screen is increased or another screen is cut in.

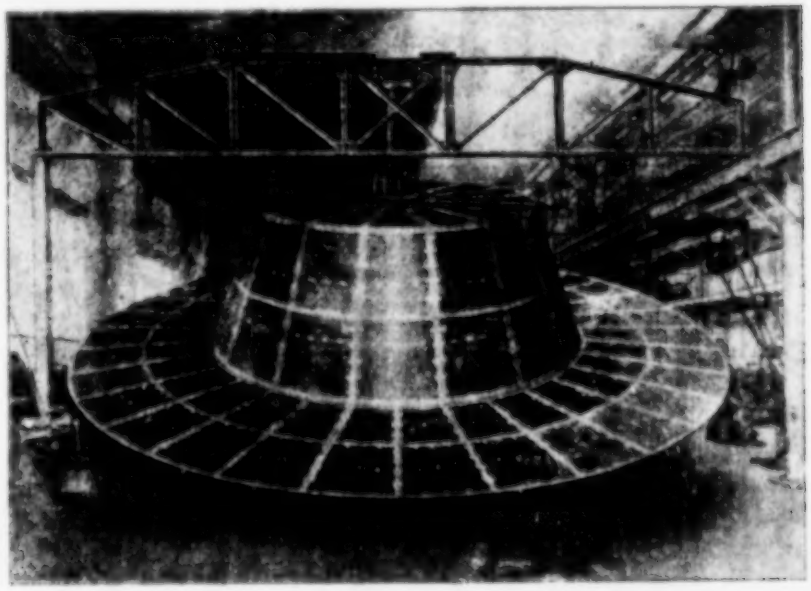
The screens are cleaned by revolving brushes, which scour the screenings off the screen into a conveyor, which discharges them into small cars in which they are conveyed to the dumps in the yard.

Each screen requires 2½ to 3 h. p. for its operation. (See Plate I for pictures and drawings of the screen.)

(Here follows diagram marked figure 23, page 26.)

Definitive Anlage Dresden

Weiterhin führe ich noch einige Photographien von Scheiben an, die augenblicklich in meiner Werkstatt ihrer Vollendung entgegensehen. Von diesen Scheiben dürfte die definitive Ausführung für die Stadt Dresden wegen ihrer ausgedehnten Dimensionen von besonderem Interesse sein. Wie aus dem in Figur 24 angegebenen Aufriß und



(Exhibit No 204)

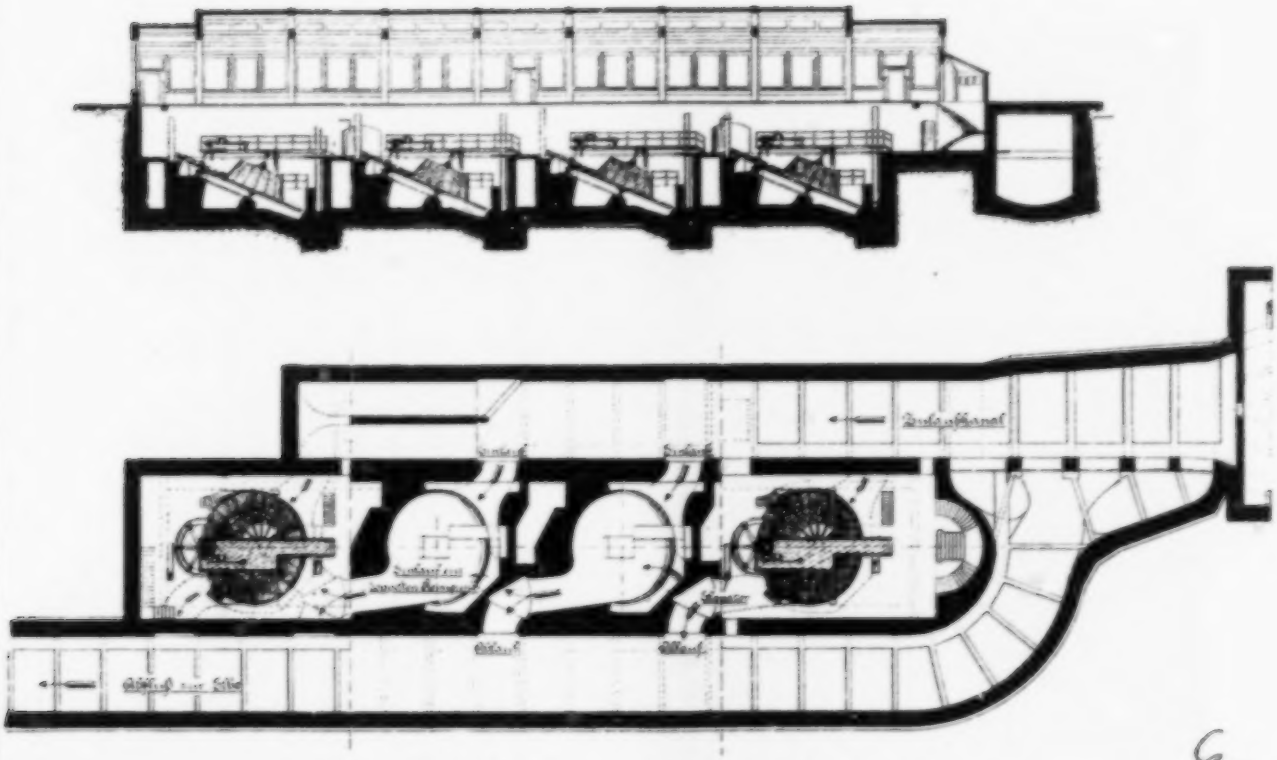
Figur 23.

Anlage Dresden in Werkstatt montiert, 8 m Durchm.

Grundriß der Kläranlage zu ersehen ist, sind für die Dresdener Ausführung zunächst 4 Scheiben von je 8 m Durchmesser vorgesehen, die zusammen im Maximalfalle 18000 Sekundenliter Schmutzwasser bewältigen. Die Scheiben sind mit gefrästen Bronzeblechen von 2 mm Schlitzweite versehen und so in den Abflußkanal eingebaut, daß sie einen Wasserstand von 2,4 m beherrschen. Einzelheiten der Scheibe sind aus der obenstehenden Figur 23 ersichtlich. Die gesamten Abwässer Dresdens durchfließen diese Reinigungsanlage und laufen alsdann ohne weitere Reinigung der Elbe zu. Bei Hochwasser werden sie nach Passieren der Separatorscheibe in die Elbe übergepumpt.

Plate I.

Screening Plant at Dresden.



Figur 24 Anlage Dresden, 4 Scheiben je 8 m Durchm.

Ex. 204

27 The pumping station is used only during times of high water in the river. It consists of nine electrically driven, two-stage centrifugal pumps, having a combined capacity of 2250 horse power.

The total cost of the disposal works without land, but including the pumping station, was two and a quarter million marks ($562,500.00).

Work Done.—I spent two days in Dresden—Saturday and Sunday, Sept. 2nd and 3rd. Saturday morning I called on Dr. Ing. Neidner in the city hall, and in the afternoon visited the sewage works, where I was shown around by Ludwig Scheitzow, the superintendent of the plant. Mr. Scheitzow spoke very good English.

General Conditions During Visit.—The two days that I spent at Dresden were both hot, clear, sunny days, with the thermometer at about 80° F. There was no rain on either day, and there had been almost no rainfall for several weeks previous. The Elbe was at its minimum stage.

Visit to Disposal Works—Sept. 2nd.—I went to the sewage disposal works by trolley along the south side of the river as far as Mohn street. From there I walked along the river, then through a suburb, and finally through open fields to the plant—a total walk of about 1.5 miles. I reached the works about 3 P. M. Mr. Scheitzow took me through the plant.

28 I learned from him that the approximate quantities of material removed from the sewage at the disposal works were as follows:

(*a*) From the two grit chambers, one cbm. (1.3 cu. yds.) daily.

(*b*) From the scum boards and bar screens, one cbms. (1.3cu. yds.) daily.

(*c*) From the revolving screens, 10 (13.0 cu. yds.) to 12 cbm. (15.7 cu. yds.) daily.

We went first to see the coarse screens and scum boards. The scum boards were not giving good results, because the velocity of sewage passing them was too great, and they were making trials with different arrangements of the boards. The sewage flowing into the plant here was quite fresh and had no strong, disagreeable smell.

At the time of my visit, only one of the disc screens was in operation, and the difference in level of the sewage on the two sides was only 30 cm. (11.8 inches.)

I was told that the disc screens sometimes required washing with a hose once every hour to remove fat and grease. At other times, one washing on each eight-hour shift is sufficient. One man can look after the ordinary operation of all four screens.

The material removed from the sewage is piled in the yard and either given away or sold as a fertilizer. The material from the grit chambers is a black, sandy substance that dries to an earth like street dirt. I examined a long pile of it in the yard, and the odor was almost imperceptible. The material from the bar screens is black and earthy, with more leaves, rags, etc., in it than in the

material from the grit chambers. I saw a long pile of this in
29 the yard, and the odor was slight. These two materials are only fair fertilizers and are given away to the farmers. The screenings from the disc screens are taken to long wooden troughs in the yard. These troughs have false bottoms built like grills, so that the liquid from the screenings can drain out and flow back to the plant. The troughs are roofed over, but not housed in. In them the screenings drain and dry, so that from 100 cbm. (130.7 cu. yds.) of raw screenings, there is left only 30 (39.2 cu. yds.) to 40 cbm. (42.3 cu. yds.) of dry material. This is said to be a very good fertilizer, and farmers take it away, paying 50 pf. a cbm. (about 10 cents per cu. yd.) There was no accumulation of it at the plant. This material was very offensive, giving off the characteristic pig-pen odor.

Attached is a very complete description of the works, dated August, 1911. The quantities given to me by the superintendent are somewhat more liberal than those quoted in the articles. This is marked Appendix VII.

Conditions of River Water Below the Plant.—I walked from the plant down along the river about one-third of a mile to the sewer outlet, and then about half a mile farther down to a ferry, where I crossed over to the north side of the river. The river water was dirty and dark-appearing all the way down. At the outlet there was no perceptible bubbling up of sewage, nor any further discoloration evident from the shore. No sea-gulls were in evidence. From the sewer outlet to the ferry, I noticed a slight but distinct odor and there were a few blotches of sleek evident on the surface.
30 Near the ferry two men on the bank were fishing and about half-a-mile below the ferry some boys were in swimming.

As I walked along, the velocity of floating particles on the surface was about 2½ to 3 miles per hour.

Around the wharf where the ferry landed, and at logs along the shore, scum collected to a slight extent.

Summary of Observations.—1. That the discharge of the effluent from the sewage screening plant of Dresden into the Elbe increased the unpleasantness of the river water.

2. That there were evidences of sewage pollution, such as the sleek which collected along the shore, the floating particles and the sewage odor.

3. That the greatest odor from the sewage treatment came from the storage and distribution of screenings.

31 **Frankfort.**

September 4th.

Description.—Frankfort is a city of about 420,000 people in Germany, on the River Main, in the southern part of Germany. The greater part of the town lies north of the river. There are no other important streams or waterways in the city. Frankfort is more of a

commercial and manufacturing city than Dresden, but not so much as Hamburg. The sewage, however, contains more solid matter than is found in the sewages of most German cities, the amount of solids being about 1300 parts per million. (For map of city see Appendix VIII.)

The city is sewered on the combined system, and the sewage from the whole city is clarified at one disposal plant located on the south side of the river, about one mile below the city. The disposal plant is located on a large tract of land owned by the city, and is not near many houses. The city refuse incinerator is adjacent to the sewage disposal works. These disposal works are different from those at Hamburg and Dresden, because in addition to removing the heavy suspended matter in the grit chamber and some of the coarser suspended matter on the screens, they also further clarify the sewage in settling basins. In this way a greater proportion of the "settleable" solids is removed, but there are more opportunities for the sewage to become septic. The percentage removal in the different stages of the clarification are given as follows, the percentages being based on the total suspended solids in the raw sewage:

32

Removed in grit chamber and screens	21%
Removed in settling basins	56%
Total removed	77%

This data is published in the accompanying descriptive pamphlet marked Appendix IX.

As is common in German cities, the sewers are well built, with good slopes, and the sewage comes to the plant in a fairly fresh condition. I should say, however, that it was not as fresh as at Dresden and Hamburg. The daily sewage flow to the plant generally varies from 85,000 cbm. (22,454,450 gal.) to 120,000 cbm. (31,700,000 gal.). The sewage from the north side is siphoned under the river to the disposal plant.

The Main was very low at the time of my visit. The quantity of water flowing in the river was given to me as follows:

Minimum flow	70 cbm. per sec. (1,597,700,160 gal. per day)
Average flow	100 " " " (2,282,428,800 " " ")
Maximum flow	300-400 cbm. per sec. (6,847,286,400—9,129,715,200 gal. per day)

At the time of my visit, it was a dark, unsightly water having a surface velocity of two to three miles per hour. I could easily walk faster than particles floating on the surface. The river is used for small boats and barges. The shipping is increasing but is not great, and the surface was smooth; there was comparatively little agitation of the water by boats. There are bathing places on the river front in the city and above the sewer outlet.

33 Disposal Works.—The sewage disposal plant consists of:
(1) A grit chamber.
(2) Three screens of the revolving paddle wheel type.
(3) Fourteen covered settling basins.
(4) Sludge pumping machinery.
(5) Centrifugal machines for drying the screenings and sludge.
(6) Conveyors, conduits, by-passes for rain water, etc.

The grit chamber and screens are located together in a house of substantial and attractive brick construction. The settling basins are covered over with an arched roof, which supports a well laid out lawn, cut with paths and gardens. There are numerous flower-beds about the plant, which is very attractive to look at. There are also attractive offices and quarters for the workmen.

The grit chamber is 6 meters (19.7 ft.) long and about 12 meters (39.4 ft.) wide, and has a bottom with rounded corners into which a cup conveyor fits. This conveyor is on a traveling carriage, so that by swinging the conveyor and moving the carriage the whole grit chamber can be cleaned. I was told at the plant that the quantity of sand removed from the grit chamber amounted to from 10 (13.0 cu. yds.) to 15 cbm. (19.9 cu. yds.) per day, and that it was cleaned daily. The grit is taken to the centrifugal machines, where it is dried and then burned in the incinerator.

There are three screens, each having five paddles and each requiring 3 h. p. to operate it. Each screen is 2 meters (6.6 ft.)
34 wide, and the clear spacing between the bars is 10 millimeters (0.39 inches). The screens are cleaned mechanically by brushes which force the leaves, rags, feces, etc., off the end of the paddles on to a belt conveyor. The screens take from 2 to 4 minutes per revolution, and the speed can be varied to suit the flow of sewage. I was told at the plant that the screens removed from 15 (19.9 cu. yds.) to 20 cbm. (26.1 cu. yds.) daily.

Each of the fourteen settling tanks is 5.8 meters (19.0 ft.) wide by about 41 meters (134.5 ft.) long and 2.5 meters (8.2 ft.) deep. The velocity of flow in them is not over 8 millimeters (0.312 inches) per second, and the period of flow is about 80 minutes. From 6 to 8 tanks are in operation at a time. Each tank is allowed to run for ten days, when the supernatant sewage is drawn off and the wet sludge is pumped to the centrifugal machines. When drawn, each tank contains about 400 cbm. (522 cu. yds.) of wet sludge. Therefore the daily quantity of sludge from each tank amounts to about 40 cbm. (52.2 cu. yds.) and with seven tanks in operation, this would amount to 280 cbm. (366 cu. yds.) daily of wet sludge. Six tanks were in operation at the time of my visit.

The bottom of each basin slopes toward two sumps, from which the sludge is pumped to the centrifugal machines. The basins are lined with white glazed brick, to avoid deposits and to facilitate cleaning. The pumping is done by two vacuum tanks, which operate like suction pumps delivering into a force main. They pump the sludge through an iron pipe 30 cm. (11.8 inches) in diameter
35 to the centrifugal machines about 200 yards away. The difference in elevation between the settling tanks and the sludge

tanks of the centrifugal machines is about 17 meters (55.7 ft.) and the dynamic head is 25 meters (82.0 ft.)

The sludge drying plant consists of four sludge tanks over the centrifugal machines, eight so-called centrifuges, a hot air drier in the basement, and the necessary hoists and conveyors for delivering the dried sludge into the hoppers over the furnaces of the incinerator. Each centrifugal machine has a capacity of 3 cbm. (3.9 cu. yds.) of wet sludge per hour, and it is necessary to keep 4 to 6 machines running every day. The drier in the basement is heated with waste gases from the incinerator.

It is interesting to note that up to the latter part of the year 1909, the sludge and screenings from the Frankfort plant were disposed of on land. On account of the unreliability of this method of sludge disposal, the centrifugal machines described above were installed. This is a costly method of disposal, but gets the sludge and screenings out of the way without great nuisance.

Work Done.—I spent only Monday, Sept. 4th, in Frankfort. In the morning I went to the city hall and talked with Ing. Schaefer, and in the afternoon I visited the disposal works, where I was shown through by the chief foreman in the absence of the superintendent.

General Conditions During Visit.—The day of my visit was a clear, hot, sunny day, with very little wind; the temperature
36 being about 80° F. There was no rain on that day and there had been almost none for several weeks previous. The Main was very low.

Visit to Disposal Works, Sept. 4.—I went to the disposal works partly by trolley and partly on foot. From the trolley I walked down along the river bank for about three-quarters of a mile. Along this part of the river there were quite a number of gardens and there were houses up to about three-eighths of a mile from the works. Just before coming to the works, I passed the unloading station, where the scows bringing the refuse boxes from the city are unloaded. The neighborhood was not critical but was not so isolated as at Dresden.

I went first into the house containing the grit chamber and screens. The velocity through this part of the works was quite rapid (say about 4 feet per second), and the odor was not bad. One of the screens was not operating on the day of my visit.

Going into the tank house, the odor was more distinct. In the masonry roof over each tank there is an opening or vent, through which the gases from the tanks escape. I afterward went close to one of these vents where it opened into the air and got no very bad smell.

Six tanks were in operation when I was at the plant, and all of them had a heavy scum, especially the main distributing channel at the center.

The centrifugal house smelled like a reduction plant, only not so strongly. This odor came from handling the dried sludge in the cars and conveyors. The odor was not so strong as the odor from the screenings at Dresden and Hamburg. The material coming
37 out of the drier was a black, moist, fine, earthy material that smelled like the tankage from a garbage reduction plant.

Condition of Main Water.—After going through the plant, I went down to the main sewage outlet below the plant. There was one seagull there, and the foreman told me there were many there during stormy weather. Two or three miles below, I could see the chimneys of a small town. The effluent was discharged about one-fourth of the width of the river from shore. The effluent was very plain to see as it "boiled" up out of the dark river water. It looked like a thick, light-brown colored liquid, and it made a long, clearly marked area in the river water, extending for at least a quarter of a mile below the point of discharge.

I was told that at this point the river was about six meters (19.7 ft.) deep and that the bottom was gravelly; and that no deposits formed on the bottom.

The odor from the effluent was faint—not as evident as at Dresden.

Summary of Observations.—1. That the discharge of the effluent from the sewage disposal works of Frankfort into the Main materially increased the unsightliness of the river water.

2. That there were evidences of sewage pollution, such as the boiling or bubbling up of the sewage plant effluent in the river water and the clearly marked sewage area extending down stream from the point of discharge.

38 3. That the city, after disposing of the sludge and screenings on land for a number of years, had gone to great expense to dry and then burn the sludge and screenings from the sewage works.

Respectfully submitted,

SAMUEL A. GREELEY.

39 APPENDIX I.

List of Drawings and Documents.

Those secured:

(1) Tide tables for Hamburg, 1911 (Appendix II.)
(2) Die Sielanlagen Hamburgs (Appendix III-A).
(3) Hamburger Förderrechen (Appendix III-B).
(4) Map of Hamburg (Appendix IV).
(5) Hamburgische Elb-Untersuchung (Appendix V).
(6) Map of Dresden (Appendix VI).
(7) Beschreibung der Anlagen zur Reinigung und Hebung der Dresdner Kanalwasser (Appendix VII).
(8) Map of Frankfort (Appendix VIII).
(9) Müllverbrennungs und Abwasserklär-Anlage Frankfort-am-Main (Appendix IX).

Those to be secured:

(1) A description of the Hamburg sewers and sewage disposal works—by Curt Merkel.

(2) Der Wasserbau—Die Eutwasserrung der Stadte—by August Frühling (gives some data on stream flow).

(3) Wasser und Abwasser—Die Hygiene der Wasserversorgung und Abwasserbeseitigung—by Kollwitz, Reichle, Schmidtman, Spitta, and Thumm. Verlag S. Hirzel, Leipzig, 1911.

(4) Maps of Germany may be secured from Die Kgl. Preussische Geologische Landesanstalt Berlin.

Photographs—Ten of sewage works at Hamburg.

APPENDIX II.

Tide Tables for Hamburg, 1911.

(Here follows reproduction of four pages of tide tables for Hamburg.

42 Hundbuch der Hygiene, by Thumm-Schmidtman, etc.

1911.

Summary of all work done at Royal Testing Station & throughout Germany.

(Exhibit No 204)

Die Finsternisse des Jahres 1911.

Im Jahre 1911 werden zwei, für unsere Gegenden nicht sichtbare, Sonnenfinsternisse stattfinden. Der Mond wird in diesem Jahre nicht verfinstert.

Die erste Sonnenfinsternis ist eine totale und ereignet sich in der Nacht vom 28. zum 29. April. Sie beginnt bei der Lord-Howe-Insel im Osten von Australien am 28. April um 8 Uhr 49 Min. abends, überstreicht die östliche Hälfte des australischen Kontinents und Neu-Seeland, zieht über die Mitte des Stillen Ozeans und erstreckt sich über Mittelamerika und die südliche Hälfte Nordamerikas. Sie endet am 29. April um 2 Uhr 6 Min. morgens in der Gegend zwischen Acapulco an der mexikanischen Küste und der Clippecton-Insel.

Die zweite Sonnenfinsternis findet am Vormittag des 22. Oktober statt. Sie ist eine ringförmige und beginnt um 2 Uhr 19 Min. morgens in der Nähe von Lahore. Das Gebiet der Sichtbarkeit erstreckt sich über den größten Teil des asiatischen Kontinents mit Ausnahme von Kleinasien, Palästina, dem westlichen Arabien und dem im Osten der Lena gelegenen Teil Sibiriens; ferner über Australien mit Ausnahme der Südwestspitze des letzten en und über die westliche Hälfte Polynesiens. Die Finsternis endet im Südosten der Salomon-Inseln um 8 Uhr 7 Min. vormittags.

Geschichtliche Erinnerungen.

Das Jahr 1911 der christlichen Ära ist das
6624. der Julianischen Periode;
5672. der Juden (Beginn desselben am 23. September, s. S. 3 u. 16);
1946. seit der Einführung des Julianischen Kalenders durch Julius Cäsar;
1841. nach der Zerstörung Jerusalems durch Titus;
1111. seit der Krönung Karls des Großen zum römischen Kaiser;
1108. seit der Gründung Hamburgs (nach alter, nicht völlig sicherer Annahme);
1125. seit Gründung des Bistums Bremen durch Karl den Großen.
1080. seit der Gründung eines Erzbistums in Hamburg durch Ludwig den Frommen;
949. seit der Krönung Otto des Ersten zum römischen Kaiser;
768. seit der Gründung des jetzigen Lübecks;
471. seit der Erfindung der Buchdruckerkunst;
458. seit dem Ende des oströmischen Kaisertums und der Eroberung Konstantinopels durch die Turken;
419. seit der Entdeckung Amerikas;
394. seit dem Beginn der Reformation durch Martin Luther;
329. seit der Kalenderverbesserung durch Papst Gregor XIII.;
290. seitdem die Neustadt (das spätere Michaelis-Kirchspiel) zur Stadt gezogen wurde;
135. seit der Einführung des „allgemeinen Reichs-Kalenders";
69 seit dem letzten großen Brand in Hamburg (5. bis 8. Mai 1842);
56. seit der letzten großen Sturmflut (20' 1");
52. seit der Einführung der neuen Verfassung in Hamburg;
43. seitdem die Vorstadt St. Georg zu Hamburg gezogen wurde;
41. laufende Jahr von der Neubegründung des Deutschen Reiches im Januar 1871 an;
23. seit dem Tode Kaiser Wilhelms I.

Mitteleuropäische Zeit. (M. E. Z.)

Alle Angaben in diesem Kalender sind auf M. E. Z. berechnet. Für Sonnen- und Mond-Auf- und Untergang gilt die Breite und der Meridian von Hamburg. Die nachfolgende Tafel gibt die Differenzen zwischen M. E. Z. und M. O. Z. Um mittlere Ortszeit zu bekommen, hat man zu den Zeitangaben des Kalenders für die folgenden Orte + zu addieren — zu subtrahieren.

Aachen	—36 Min.	Düsseldorf	—33 Min.	Karlsruhe	—26 Min.	Plauen	—11 Min.
Altona	—20 "	Elberfeld	—31 "	Kassel	—22 "	Posen	+ 8 "
Augsburg	—16 "	Elbing	+18 "	Kiel	—19 "	Potsdam	— 8 "
Barmen	—31 "	Erfurt	—16 "	Köln	—32 "	Prag	— 2 "
Basel	—30 "	Essen	—32 "	Königsberg	+22 "	Regensburg	—12 "
Berlin	— 6 "	Flensburg	—22 "	Krefeld	—34 "	Rostock	—11 "
Bern	—30 "	Frankf. a. M.	—25 "	Leipzig	—10 "	St. Gallen	—25 "
Bochum	—31 "	Frankf. a. O.	— 2 "	Liegnitz	+ 5 "	Schwerin	—14 "
Bonn	—32 "	Freiburg i. B.	—29 "	Lübeck	—17 "	Stettin	— 2 "
Braunschweg.	—18 "	Fürth	—16 "	Magdeburg	—15 "	Straßburg E.	—29 "
Bremen	—25 "	Genf	—35 "	Mainz	—27 "	Stuttgart	—23 "
Breslau	+ 8 "	Gera	—12 "	Mannheim	—26 "	Trier	—33 "
Bromberg	+12 "	Gießen	—25 "	Memel	—24 "	Triest	— 5 "
Charlottenb.	— 7 "	Görlitz	— 0 "	Metz	—35 "	Ulm	—20 "
Chemnitz	— 8 "	Gotha	—17 "	Mülhausen E.	—30 "	Weimar	—15 "
Cuxhaven	—25 "	Graz	+ 2 "	München	—14 "	Wien	+ 5 "
Danzig	—15 "	Halle a. S.	—12 "	M.-Gladbach	—34 "	Wiesbaden	—27 "
Darmstadt	—25 "	Hamburg	—20 "	Münster	—29 "	Winterthur	—25 "
Dortmund	—30 "	Hannover	—21 "	Nürnberg	—16 "	Würzburg	—20 "
Dresden	— 5 "	Heidelberg	—25 "	Oldenburg	—27 "	Zürich	—26 "
Duisburg	—33 "	Helgoland	—28 "	Osnabrück	—28 "	Zwickau	—10 "

Eintritt der Flut und Ebbe in Hamburg 1911.

Niedrigwasser = Eintritt der Flut. Hochwasser = Eintritt der Ebbe.

Datum	Januar				Februar				März				April				Mai				Juni			
	Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag	
	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe
1.	1 ⅓	5¾	1½	6	2¼	6¾	2½	7¼	1¼	5⅔	1½	6¼	2	6¾	2½	7	2¼	6¾	2½	7¼	3½	8	4	8½
2.	1¾	6½	2¼	6¾	2⅔	7½	3¼	7⅔	2	6½	2¼	6¾	2¾	7¼	3	7½	3	7½	3⅓	7¾	4¼	9	4¾	9¼
3.	2½	7	2¾	7¼	3½	8	3¾	8¼	2½	7	3	7½	3¼	8	3¼	8¼	3¾	8¼	4	8¾	5	9¼	5½	10¼
4.	3	7½	3¼	8	4	8¼	4½	9	3¼	7¾	3½	8	4	8½	4⅓	9	4½	9	4⅔	9½	6	10¾	6¼	11¼
5.	3¾	8¼	4	8½	4¾	9¼	5	9¾	3¾	8¼	4	8¾	4½	9¼	5	9½	5¼	10	5⅔	10½	7	12	7½	—
6.	4⅛	9	4¾	9¼	5⅓	10	5⅔	10½	4½	9	4¾	9¾	5¼	10	5¾	10½	6⅓	11	6¾	11¾	8¼	12½	8⅔	1
7.	5	9¾	5⅓	10	6	10⅔	6¼	11	5	9½	5¼	10	6¼	11	6¾	11⅔	7½	—	8¼	12¼	9¼	1¾	10	2½
8.	5½	10½	6	10¾	6¾	11½	7¼	—	5½	10¼	6	10¾	7½	—	8⅛	12½	9	1	9½	1⅝	10¼	2¾	10¾	3¼
9.	6½	11⅓	6¾	11⅔	7⅔	12¼	8½	12¾	6¼	11¼	7	11¾	9¼	1⅓	10	2	10¼	2½	10¾	3	11¼	3½	11¾	4
10.	7⅓	—	7¾	12⅓	9¼	1½	10	2⅔	7½	—	8⅓	12½	10½	2¾	11¼	3½	11⅓	3½	11½	3¾	—	4⅛	12	4¼
11.	8½	12⅔	9¼	1½	10¾	3	11½	3½	9¼	1⅝	10	2	11½	4	—	4⅓	12	4¼	—	4½	12½	5	12¾	5⅓
12.	9¾	2	10½	2½	12	4	—	4¾	10¾	2¾	11½	3½	12	4¾	12½	5	12¼	5	12½	5¼	1	5⅝	1⅓	6
13.	11	3¼	11½	3¾	12½	5⅓	1	5½	12	4	—	4½	12¾	5½	1	5¼	1	5½	1¼	5¾	1¾	6¼	2	6½
14.	—	4¼	12¼	4⅔	1½	6	1⅓	6½	12½	5	12¾	5½	1½	6	1⅔	6¼	1½	6	1⅝	6¼	2¼	6¾	2½	7
15.	12⅓	5¼	1¼	5⅔	2¼	6¾	2¾	7¼	1¼	5¾	1½	6⅓	2	6½	2⅓	6¾	2	6½	2¼	6¾	2¾	7¼	3	7⅓
16.	1½	6¼	2	6½	3	7½	3¼	7⅔	2	6½	2¼	6⅔	2½	7	2¾	7¼	2½	7	2¾	7½	3¼	8	3½	8¼
17.	2½	7	2⅔	7½	3½	8	3¾	8½	2½	7	2¾	7¼	3	7½	3¼	7¾	3	7½	3½	8	4	8½	4⅓	8¼
18.	3¼	7⅔	3½	8¼	4	8¾	4¼	9	3	7½	3¼	7¾	3½	8	3¾	8¼	3½	8¼	3¾	8½	4½	9¼	5	9½
19.	4	8½	4¼	8¾	4½	9¼	4¾	9½	3½	8	3¾	8¼	4	8½	4¼	8¾	4	8¾	4½	9	5¼	10	5½	10½
20.	4½	9¼	4¾	9½	5	9¾	5¼	10	4	8½	4⅓	8¾	4½	9	4¾	9½	4¾	9½	5	9¾	6	10¾	6½	11¼
21.	5¼	9¾	5½	10¼	5½	10¼	5¾	10¾	4¼	9	4¾	9¾	5	9¾	5½	10¼	5½	10¼	6	10¾	7	11¼	7½	—
22.	5¾	10½	6	10¾	6¼	11	6½	11½	5	9½	5¼	10	6	10¾	6½	11¼	6½	11¼	7	12	8	12⅓	8½	1
23.	6¼	11	6¾	11½	7	12	7½	—	5½	10¼	6	10¾	7	12	7¾	—	7½	—	8⅓	12½	9¼	1½	9¾	2
24.	7	12	7½	—	8¼	12½	9	1¼	6¼	11¼	7	11⅔	8¼	12½	9	1¼	9	1½	9½	1⅔	10¼	2½	10¾	3⅓
25.	8	12½	8¾	1	9¾	1¾	10¼	2½	7½	—	8¼	12½	9¾	2	10¼	2½	10	2½	10½	3	11⅓	3½	12	4
26.	9¼	1½	9½	2¼	11	3¼	11½	3¾	9	1¼	9¾	2	10¾	3¼	11¼	3½	11	3½	11½	3¾	—	4½	12½	5
27.	10½	2¾	11	3¼	12	4¼	—	4¾	10¼	2½	11	3½	11¾	4	—	4½	12	4¼	—	4½	12¾	5½	1⅓	6
28.	11½	3¾	12	4¼	12½	5	12¾	5½	11½	3⅔	12	4¼	12¼	4¾	12½	5	12¼	5	12¾	5½	1¾	6¼	2¼	6¾
29.	—	4¾	12½	5					—	4¾	12½	5	12¾	5½	1⅓	5¾	1¼	5¾	1½	6¼	2¾	7¼	3	7½
30.	12¾	5½	1¼	5¾					12¾	5½	1¼	5¾	1½	6¼	2	6½	2	6½	2¼	7	3½	8	3¾	8½
31.	1½	6¼	2	6½					1½	6	1¾	6¼					2⅔	7¼	3¼	7¾				

Eintritt der Flut und Ebbe in Hamburg 1911. Niedrigwasser = Eintritt der Flut. Hochwasser = Eintritt der Ebbe.

Tag	Juli				August				September				Oktober				November				Dezember			
	Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag	
	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe
1.	4 1/4	8 3/4	4 1/2	9 1/4	5 1/4	9 3/4	5 1/2	10 1/4	5 1/2	10 1/4	5 3/4	10 3/4	5 3/4	10 1/2	6 1/4	11	7 1/2	—	8 1/4	12 1/2	7 3/4	12	8 1/2	12 3/4
2.	5	9 1/2	5 1/4	10	5 3/4	10 1/2	6	10 3/4	6 1/4	11 1/4	6 3/4	11 3/4	6 3/4	11 3/4	7 1/2	—	8 3/4	1	9 1/2	1 3/4	9	1 1/4	9 1/2	2
3.	5 1/2	10 1/2	6	10 3/4	6 1/4	11	6 3/4	11 1/2	7 1/4	—	8	12 1/4	8 1/4	12 1/2	9	1	10	2 1/4	10 1/2	2 3/4	10 1/4	2 1/2	10 1/2	3
4.	6 1/4	11 1/4	6 3/4	11 1/2	7	—	7 3/4	12	8 1/4	1	9 1/2	1 3/4	9 1/2	1 3/4	10 1/4	2 1/2	11	3 1/4	11 1/4	3 3/4	11	3 1/2	11 1/2	3 3/4
5.	7 1/4	—	7 1/2	12	8 1/4	12 1/2	9	1 1/4	10 1/4	2 1/4	10 3/4	3	10 3/4	3	11 1/4	3 1/2	11 3/4	4	—	4 1/2	11 3/4	4	—	4 1/2
6.	8 1/4	12 1/2	8 3/4	1	9 1/2	1 3/4	10 1/4	2 1/2	11 1/4	3 1/2	11 3/4	4	11 3/4	4	—	4 1/2	12 1/4	4 3/4	12 1/2	5	12 1/4	5	12 3/4	5 1/4
7.	9 1/4	1 3/4	10	2 1/4	10 3/4	3	11 1/4	3 1/2	—	4 1/2	12 1/4	5	12	4 3/4	12 1/2	5	12 3/4	5 1/2	1 1/4	5 1/4	1	5 3/4	1 1/2	6
8.	10 1/2	2 3/4	11	3 1/4	11 3/4	4	—	4 1/2	12 3/4	5 1/4	1	5 1/2	12 3/4	5 1/4	1	5 3/4	1 1/2	6	1 3/4	6 1/2	2	6 1/2	2 1/4	7
9.	11 1/2	3 3/4	11 3/4	4	12 1/4	5	12 3/4	5 1/4	1 1/4	6	1 1/2	6 1/4	1 1/2	6	1 3/4	6 1/4	2 1/4	6 3/4	2 1/2	7	2 1/4	7 1/4	3 1/4	7 3/4
10.	—	4 1/2	12 1/4	5	1	5 1/2	1 1/2	6	2	6 1/2	2 1/4	6 3/4	2	6 1/2	2 1/4	7	2 3/4	7 1/2	3 1/4	7 3/4	3 1/2	8 1/4	4	8 1/2
11.	12	5 1/4	1	5 1/2	1 3/4	6 1/4	2	6 1/2	2 1/2	7	2 3/4	7 1/4	2 1/2	7 1/4	3	7 1/2	3 3/4	8 1/4	4	8 3/4	4 1/2	9	4 3/4	9 1/2
12.	1 1/4	6	1 3/4	6 1/4	2 1/4	7	2 1/2	7 3/4	3	7 1/2	3 1/4	8	3 1/4	7 3/4	3 1/2	8	4 1/2	9	4 3/4	9 1/2	5	9 3/4	5 1/2	10 1/4
13.	2	6 1/2	2 1/4	6 3/4	3	7 1/2	3 1/4	7 3/4	3 3/4	8 1/4	4	8 1/2	3 3/4	8 1/2	4 1/4	8 3/4	5 1/4	10	5 3/4	10 1/2	6	10 3/4	6 1/2	11 1/4
14.	2 1/2	7 1/4	2 3/4	7 1/2	3 1/2	8	3 3/4	8 1/4	4 1/4	8 3/4	4 1/2	9	4 1/2	9 1/4	4 3/4	9 1/2	6 1/4	11	7	11 3/4	7	12	7 1/2	—
15.	3 1/4	7 3/4	3 1/2	8	4	8 3/4	4 1/4	9	4 3/4	9 1/2	5	9 3/4	5 1/4	10	5 3/4	10 1/2	7 1/2	—	8 1/4	12 1/2	8	12 1/2	8 3/4	1
16.	3 3/4	8 1/4	4	8 1/2	4 1/2	9 1/4	5	9 1/2	5 1/2	10 1/4	5 3/4	10 1/2	6 1/4	11 1/4	7	12	9	1 1/4	9 1/2	2	9 1/4	1 3/4	9 3/4	2 1/4
17.	4 1/4	9	4 3/4	9 1/4	5 1/4	10	5 1/2	10 1/4	6 1/4	11 1/4	7	12	7 3/4	—	8 1/2	12 3/4	10 1/4	2 1/2	10 1/2	3	10 1/4	2 3/4	10 3/4	3
18.	5	9 3/4	5 1/4	10	5 3/4	10 1/2	6 1/4	11	7 3/4	—	8 1/2	12 3/4	9 1/2	1 1/2	10	2 1/4	11	3 1/2	11 1/2	3 3/4	11 1/4	3 1/2	11 3/4	4
19.	5 1/2	10 1/4	6	10 3/4	6 1/2	11 1/2	7 1/4	—	9 1/2	1 1/2	10 1/4	2 1/4	10 3/4	2 3/4	11 1/4	3 1/2	11 3/4	4 1/4	—	4 1/2	—	4 1/4	12	4 1/2
20.	6 1/4	11	6 3/4	11 1/2	7 1/4	12	8 1/2	12 3/4	10 3/4	3	11 1/2	3 1/2	11 3/4	4	—	4 1/4	12 1/4	4 3/4	12 1/2	5 1/4	12 1/2	5	12 3/4	5 1/2
21.	7 1/4	—	7 3/4	12	9 1/4	1 1/2	10 1/4	2 1/4	12	4	—	4 1/2	12	4 3/4	12 1/2	5	1	5 1/2	1 1/4	5 3/4	1	5 1/4	1 1/2	6
22.	8 1/4	12 3/4	9	1 1/4	10 3/4	3	11 1/2	3 1/2	12 1/2	5	12 1/4	5 1/2	12 3/4	5 1/4	1	5 1/2	1 1/2	6	1 3/4	6 1/4	1	5 3/4	1 1/2	6
23.	9 3/4	2	10 1/4	2 1/2	—	4 1/4	12	4 3/4	1 1/4	5 3/4	1 1/2	6 1/4	1 1/4	6	1 3/4	6 1/4	2	6 1/2	2 1/4	6 3/4	2 1/4	7	2 3/4	7 1/4
24.	11	3 1/4	11 1/2	3 3/4	12 1/2	5 1/4	1	5 3/4	2	6 1/2	2 1/4	6 3/4	2	6 1/2	2 1/4	6 3/4	2 1/2	7	2 3/4	7 1/2	3	7 1/2	3 1/4	7 3/4
25.	—	4 1/4	12 1/4	4 3/4	1 1/2	6	2	6 1/2	2 1/2	7	2 3/4	7 1/4	2 1/2	7	2 3/4	7 1/4	3	7 3/4	3 1/4	8	3 1/2	8	3 3/4	8 1/4
26.	12 3/4	5 1/4	1 1/4	5 3/4	2 1/4	6 3/4	2 1/2	7 1/4	3	7 1/2	3 1/4	7 3/4	3	7 1/2	3 1/2	7 3/4	3 1/2	8	3 3/4	8 1/4	4	8 1/2	4 1/4	9
27.	1 1/4	6 1/4	2	6 3/4	3	7 1/2	3 1/2	7 3/4	3 1/2	8	3 3/4	8 1/2	3 1/2	8	3 3/4	8 1/4	4 1/4	9	4 1/2	9 1/4	4 1/2	9 1/4	5	9 3/4
28.	2 1/2	7	3	7 1/2	3 1/2	8	3 3/4	8 1/4	4	8 1/2	4 1/4	8 3/4	4	8 1/2	4 1/2	9	5	9 3/4	5 1/4	10	5 1/4	10	5 3/4	10 1/2
29.	3 1/4	7 3/4	3 1/2	8 1/4	4	8 3/4	4 1/4	9	4 1/4	9	4 1/2	9 1/4	4 1/2	9 1/4	5	9 3/4	5 3/4	10 1/2	6	11	6	10 3/4	6 1/4	11 1/4
30.	4	8 1/2	4 1/4	9	4 1/2	9 1/4	4 3/4	9 1/2	5	9 3/4	5 1/4	10	5 1/4	10	5 1/2	10 1/2	6 3/4	11 1/2	7 1/2	—	6 3/4	11 3/4	7 1/4	—
31.	4 1/2	9 1/4	5	9 1/2	5	9 3/4	5 1/4	10					6 1/4	11	6 1/4	11 3/4					7 3/4	12 1/4	8 1/2	12 3/4

(Exhibit No 209)

19

Eintritt der Flut und Ebbe in Cuxhaven 1911.

Niedrigwasser = Eintritt der Flut. Hochwasser = Eintritt der Ebbe.

Datum	Januar				Februar				März				April				Mai				Juni			
	Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag		Vormittag		Nachmittag	
	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe	Flut	Ebbe
1.	8 ⅛	1 ½	8 ¾	1 ¾	9 ½	2 ½	9 ⅝	2 ⅝	8 ½	1 ½	8 ¾	2	9 ¼	2 ½	9 ½	2 ⅔	9 ½	2 ½	9 ⅔	3	10 ⅛	3 ⅛	11 ⅓	4 ⅛
2.	9	2	9 ⅛	2 ½	10	3 ¼	10 ¼	3 ½	9	2 ⅛	9 ½	2 ½	10	3	10 ¼	3 ¼	10 ¼	3 ¼	10 ½	3 ½	11 ½	4 ⅛	12	5
3.	9 ½	2 ⅜	10	3	10 ½	3 ¾	11	4	9 ¾	2 ⅝	10	3 ¼	10 ½	3 ½	10 ¾	4	11	4	11 ¼	4 ½	—	5 ½	12 ¼	6
4.	10 ¼	3 ¼	10 ½	3 ¾	11 ¼	4 ½	11 ½	4 ⅝	10 ¼	3 ½	10 ¾	3 ⅝	11 ¼	4 ¼	11 ½	4 ½	11 ¾	4 ⅜	—	5 ¼	12 ¾	6 ½	1 ⅛	7
5.	10 ¾	4	11 ¼	4 ⅛	11 ¾	5	—	5 ½	11	4	11 ¼	4 ½	11 ¾	5	—	5 ¼	12	5 ½	12 ½	6 ¼	1 ¼	7 ½	2 ½	8 ⅛
6.	11 ½	4 ¾	11 ¾	5	12 ¼	5 ¾	12 ½	6	11 ½	4 ¾	11 ¾	5	12	5 ¾	12 ½	6 ¼	1	6 ¾	1 ½	7 ¼	3	8 ¾	3 ½	9 ½
7.	—	5 ¼	12 ¼	5 ¾	12 ¾	6 ½	1 ⅛	6 ¾	—	5 ⅛	12	5 ¾	1	6 ⅞	1 ¾	7 ½	2 ¼	8	3	8 ⅜	4 ⅛	10	4 ⅝	10 ½
8.	12 ½	6	12 ¾	6 ½	1 ½	7 ⅛	2	7 ¾	12 ⅜	6	12 ¾	6 ½	2 ½	8 ¼	3 ¼	9	3 ¾	9 ½	4 ½	10	5 ¼	11	5 ¾	11 ⅛
9.	1 ¼	7	1 ¾	7 ½	2 ⅜	8 ½	3 ¼	9 ¼	1 ¼	6 ¾	1 ¾	7 ½	4	9 ¾	4 ⅜	10 ½	5	10 ¾	5 ½	11 ¼	6	11 ¾	6 ½	—
10.	2 ¼	8	2 ¾	8 ½	4 ¼	9 ¾	5	10 ½	2 ½	8 ⅛	3 ¼	9	5 ½	11	6	11 ½	6	11 ½	6 ½	12	7	12	7 ⅛	12 ½
11.	3 ¼	9	4	9 ¼	5 ½	11 ¼	6 ¼	11 ¾	4	9 ¾	4 ¾	10 ½	6 ½	—	7	12	6 ¾	—	7 ⅛	12 ¼	7 ½	12 ¾	8	1
12.	4 ½	10 ¼	5 ¼	11	6 ¾	—	7 ⅛	12 ¼	5 ½	11 ¼	6 ⅛	11 ⅞	7 ¼	12 ½	7 ⅞	12 ¾	7 ½	12 ¾	7 ¾	1	8 ¼	1 ¼	8 ½	1 ⅝
13.	5 ¾	11 ½	6 ½	12	7 ¾	12 ¾	8 ⅛	1 ¼	6 ¾	—	7 ⅛	12 ¼	8	1 ⅛	8 ⅛	1 ½	8	1 ¼	8 ¼	1 ½	8 ¾	2	9	2 ⅛
14.	7	—	7 ⅛	12 ½	8 ¾	1 ⅛	9	2 ¼	7 ¾	12 ¾	8	1 ¼	8 ½	1 ⅜	8 ⅝	2	8 ½	1 ⅝	9	2	9 ½	2 ½	9 ¾	2 ¾
15.	8	1	8 ½	1 ½	9 ½	2 ½	9 ¾	3	8 ½	1 ½	8 ¾	1 ¾	9	2 ¼	9 ¼	2 ½	9 ¼	2 ¼	9 ½	2 ½	10	3	10 ¼	3 ¼
16.	9	2	9 ¼	2 ¼	10	3 ¼	10 ½	3 ½	9	2 ¼	9 ¼	2 ½	9 ½	2 ¾	9 ¾	3	9 ¾	2 ¾	10	3	10 ½	3 ¾	10 ¾	4
17.	9 ¾	2 ¾	10	3	10 ¾	3 ¾	11	4	9 ¾	2 ⅝	10	3	10	3 ¼	10 ¼	3 ½	10 ½	3 ¼	10 ½	3 ½	11	4 ⅛	11 ⅓	4 ½
18.	10 ½	3 ½	10 ¼	4	11 ¼	4 ½	11 ½	4 ⅜	10 ¾	3 ¼	10 ½	3 ½	10 ½	3 ¾	10 ⅔	4	10 ¾	3 ¾	11	4 ¼	11 ⅜	4 ⅜	—	5 ¼
19.	11	4 ¼	11 ½	4 ½	11 ¾	5	12	5 ¼	10 ½	3 ⅝	10 ¾	4	11	4 ⅛	11 ¼	4 ½	11 ¼	4 ½	11 ¾	4 ¾	12	5 ½	12 ½	6
20.	11 ¾	5	12	5 ¼	—	5 ½	12 ¼	5 ¾	11	4 ¼	11 ¼	4 ½	11 ½	4 ⅜	12	5 ¼	12	5 ⅛	—	5 ½	12 ⅜	6 ½	1 ¼	7
21.	—	5 ½	12 ¼	5 ¾	12 ½	6	12 ¾	6 ¼	11 ½	4 ⅜	11 ¾	5	—	5 ½	12 ¼	6	12 ¼	6	12 ¾	6 ½	1 ⅜	7 ½	2 ⅛	8
22.	12 ½	6 ¼	12 ¾	6 ⅝	1	6 ¾	1 ½	7 ¼	—	5 ¼	12	5 ⅝	12 ⅜	6 ½	1 ⅜	7	1 ⅜	7	1 ¾	7 ½	2 ⅜	8 ⅛	3 ⅛	9 ¼
23.	1 ⅜	6 ⅜	1 ½	7 ⅛	2	7 ¾	2 ½	8 ⅛	12 ½	6	12 ¾	6 ½	1 ⅜	7 ½	2 ½	8 ⅛	2 ½	8 ⅛	3 ¼	9	4	9 ⅜	4 ⅜	10 ⅛
24.	2	7 ⅜	2 ½	8 ¼	3	9	3 ⅜	9 ½	1 ⅜	7	1 ⅜	7 ⅝	3 ⅛	9	4	9 ⅝	3 ⅜	9 ½	4 ½	10	5 ⅛	10 ⅜	5 ⅜	11 ¼
25.	3	8 ¼	3 ½	9 ¼	4 ½	10 ⅜	5 ⅛	10 ⅜	2 ½	8 ½	3	9	4 ½	10 ¼	5 ⅛	10 ⅞	5	10 ⅜	5 ½	11 ¼	6 ¼	11 ⅜	6 ⅜	—
26.	4 ⅛	10	4 ¾	10 ½	5 ⅜	11 ½	6 ⅛	12	3 ⅜	9 ½	4 ⅛	10 ⅛	5 ⅜	11 ¼	6 ¼	11 ⅜	6	11 ½	6 ¼	11 ⅜	7 ¼	12 ¼	7 ⅜	12 ⅜
27.	5 ¼	11	5 ¾	11 ½	6 ⅜	—	7 ¼	12 ¼	5 ¼	11	5 ¾	11 ½	6 ½	—	7	12 ⅛	6 ⅝	—	7 ⅛	12 ⅜	8	1	8 ⅜	1 ⅛
28.	6 ⅜	12	6 ¾	—	7 ⅜	12 ⅝	8	1 ¼	6 ¾	12	6 ⅝	—	7 ¼	12 ½	7 ⅞	12 ⅝	7 ½	12 ⅜	8	1	9	2	9 ½	2 ½
29.	7 ¼	12 ⅛	7 ¾	12 ⅝					7 ¾	12 ¼	7 ¼	12 ⅝	8	1 ¼	8 ½	1 ½	8 ½	1 ½	8 ¾	1 ⅝	10	3	10 ¼	3 ⅛
30.	8	1 ¼	8 ⅛	1 ½					8	1	8 ¾	1 ½	8 ¼	1 ⅜	9	2 ¼			9 ⅜	2 ¼	10 ⅛	3 ⅜	11	4 ⅛
31.	8 ¾	2	9	2 ⅛					8 ¼	1 ⅜	9	2							10	3				

(Exhibit No 204)

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

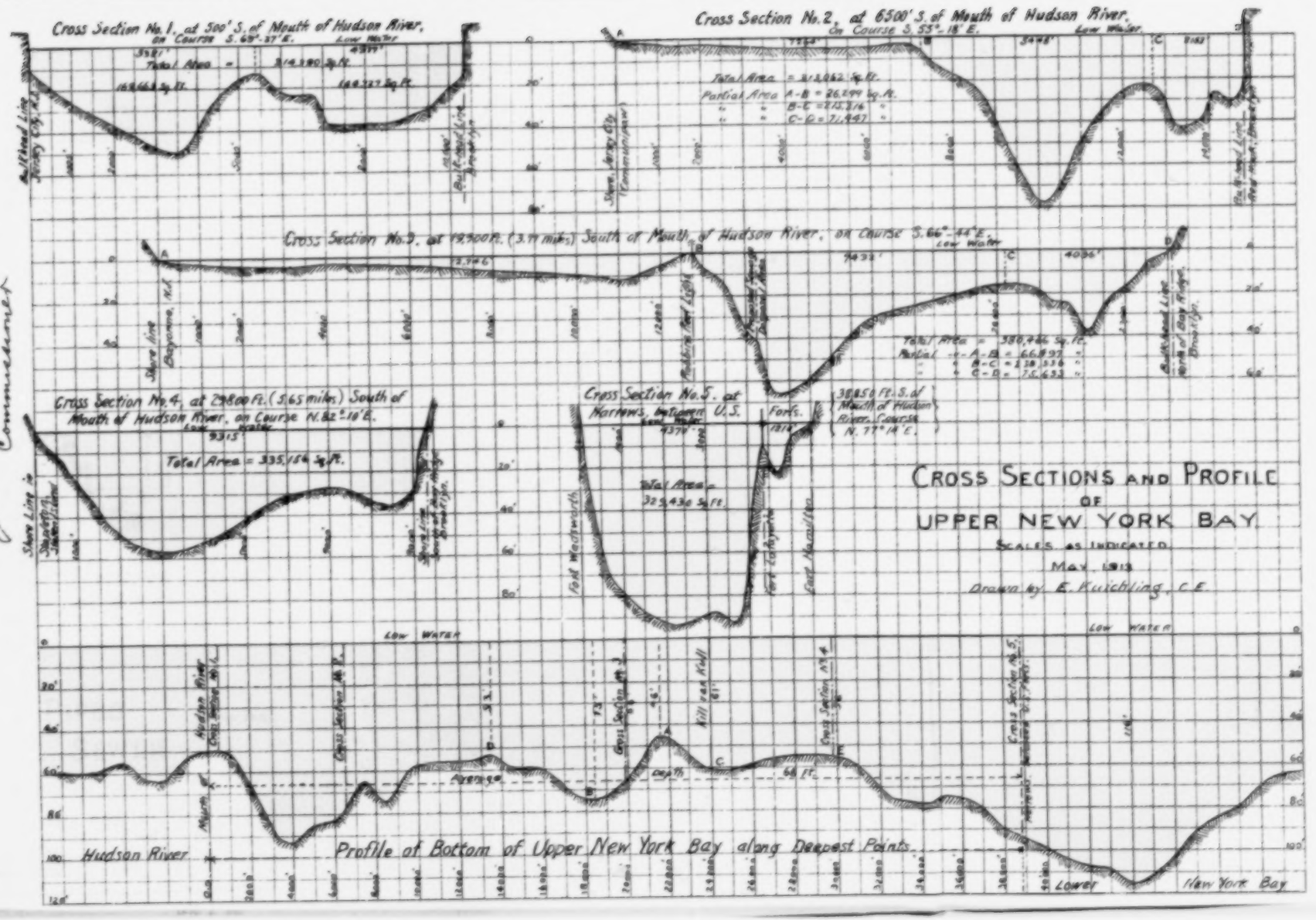
STATE OF NEW JERSEY ET AL.

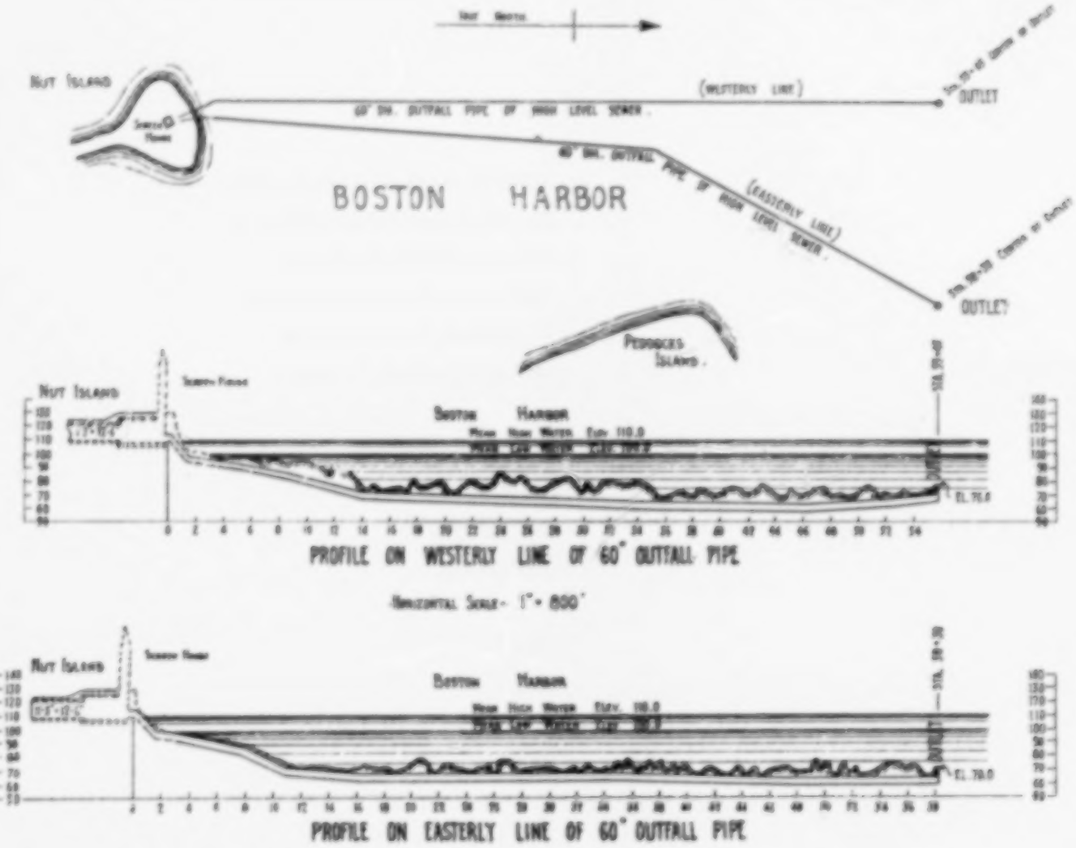
HERE FOLLOW COMPLAINANTS' EXHIBITS

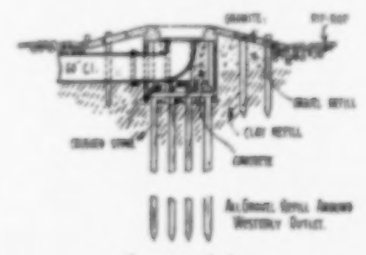
Nos. 205, 206, 207, 208, 209, 210, 211, 211a, 212a, 212b, 212c, 212d, 213, and 214.

JAMES D. MAHER,
Commissioner.

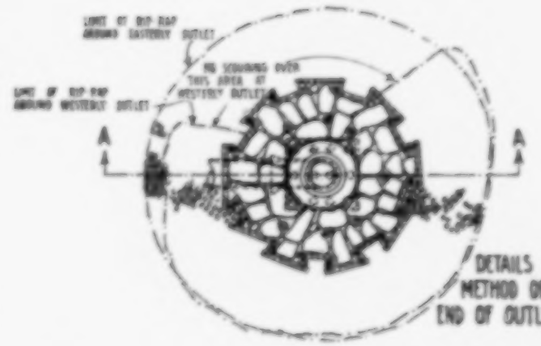
Complainant's Exhibit No. 205
James N. Walker
Commissioner







SECTION A-A
(WESTERLY OUTLET)



DETAILS SHOWING METHOD OF SECURING END OF OUTLET PIPE.

PLAN

OUTFALL PIPES
HIGH LEVEL SEWER

SOUTH METROPOLITAN SEWERAGE WORKS

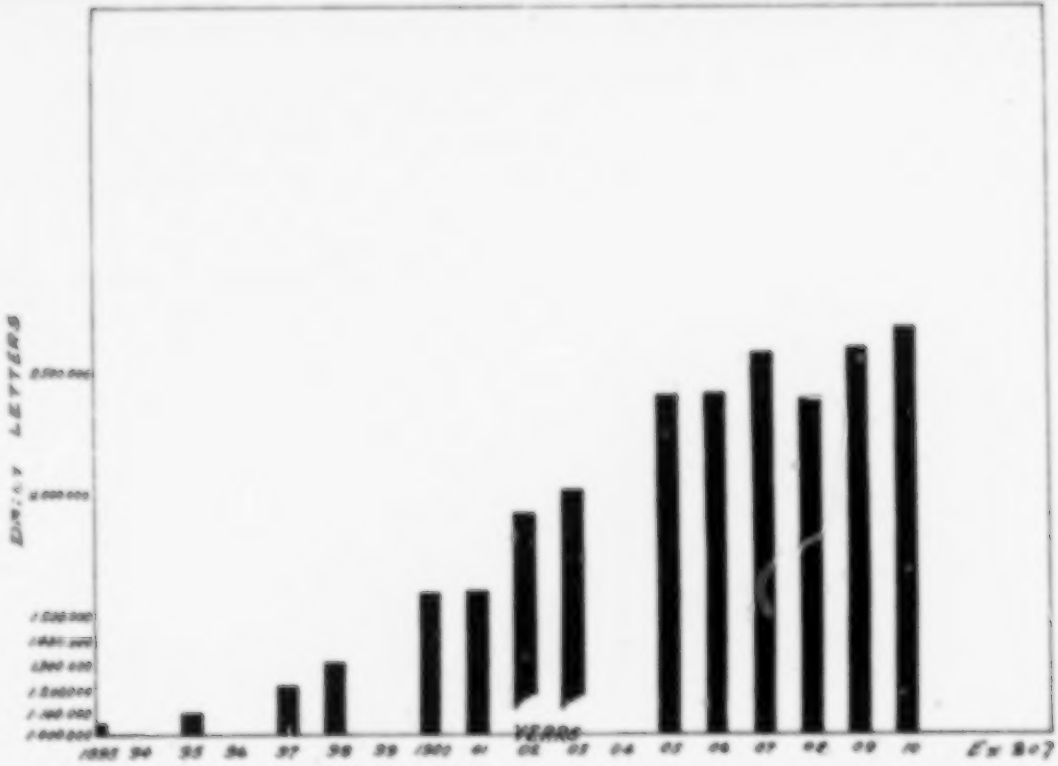
SCALE- AS SHOWN. JUNE 2, 1913.

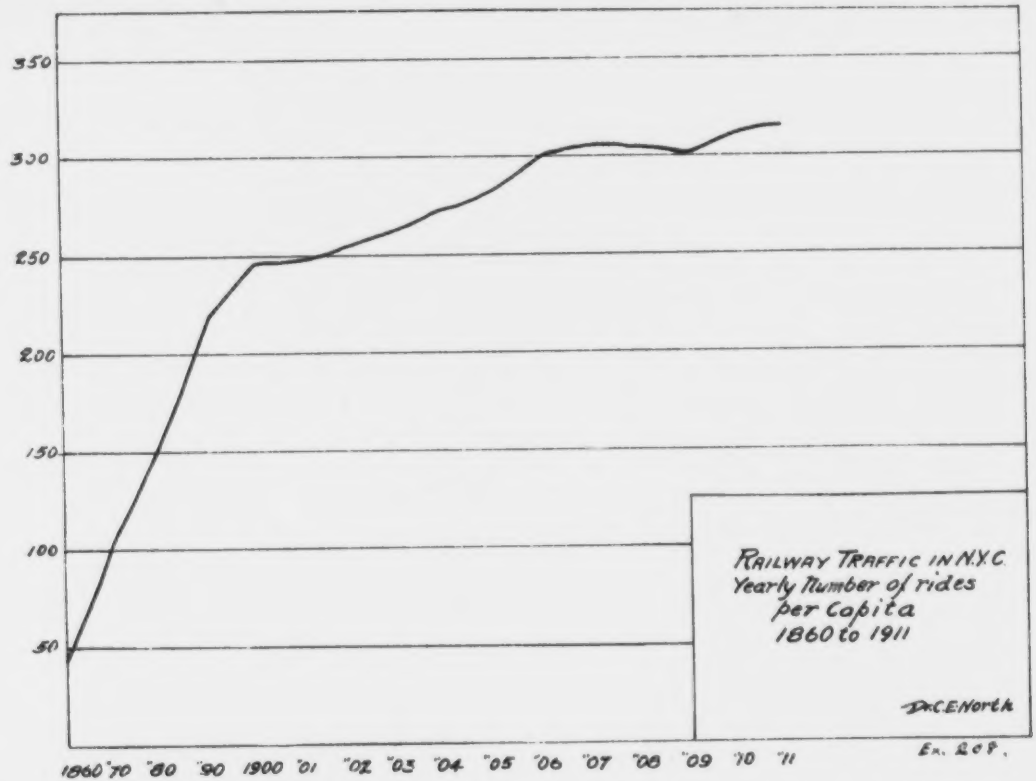
METCALF & EDDY
Consulting Civil Engineers
BOSTON - CHICAGO.

Complements to Exhibit No. 206
James D. Maher
Commissioner

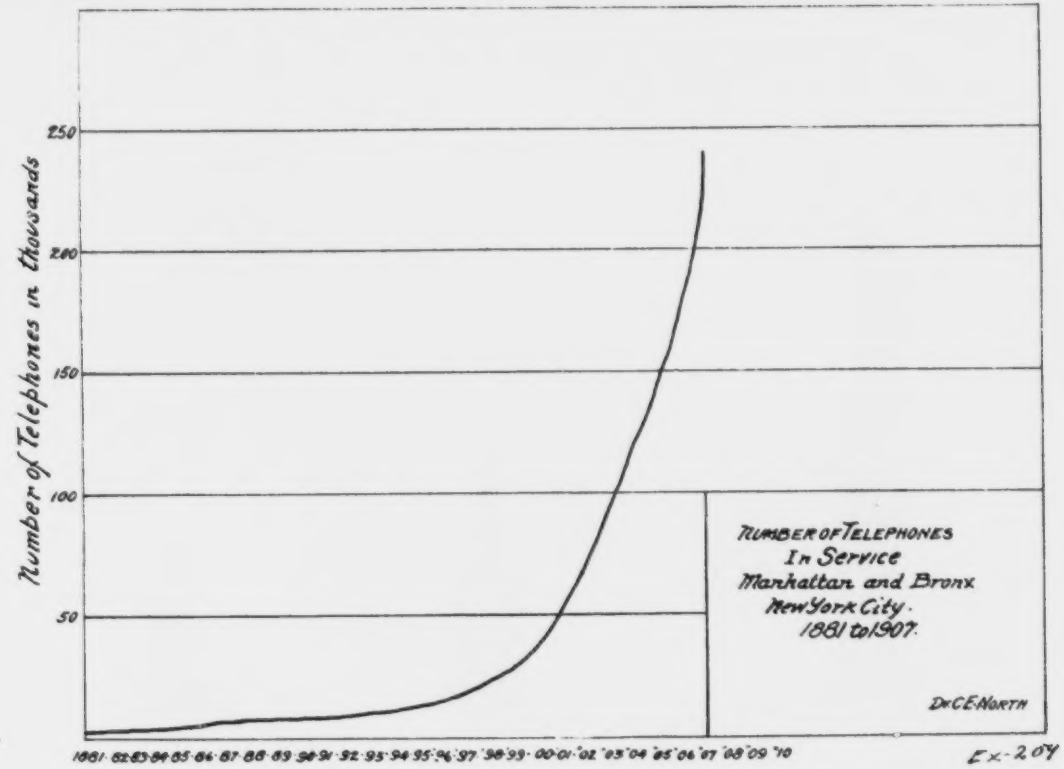
COMPILED FROM RECORD PLANS — SECTION 43
SHEETS NOS. 1 AND 2 - BOSTON NOV. 1914
SIGNED... WM. M. BROWN... ENG. TOPOGRAPHIC WORKS

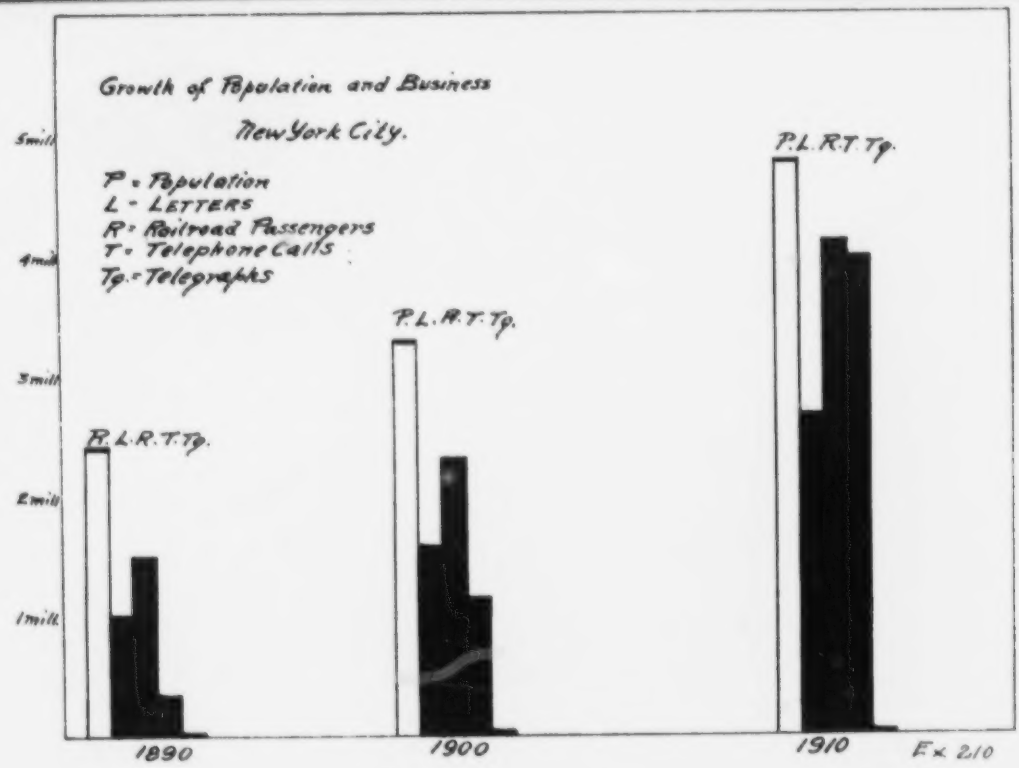
DEDR-7-447


LETTERS
YEARS


350
300
250
200
150
100
50
1860 '70 '80 '90 1900 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11
RAILWAY TRAFFIC IN N.Y.C.
Yearly Number of rides
per Capita
1860 to 1911
Dr. C.E. North
Ex. 208.

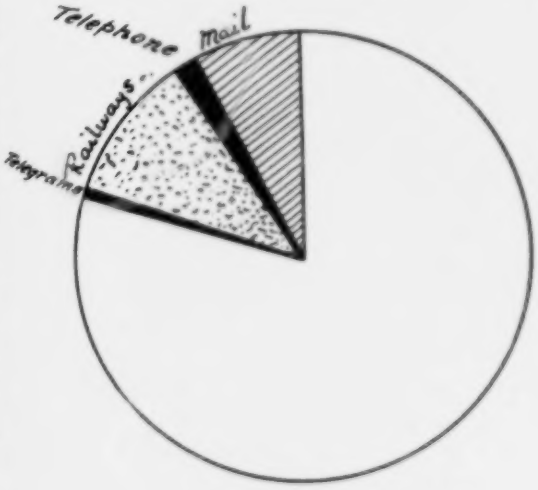



Number of Telephones in thousands
250
200
150
100
50
1881 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10
Number of Telephones
In Service
Manhattan and Bronx
New York City.
1881 to 1907.
Dr C E North
Ex-204

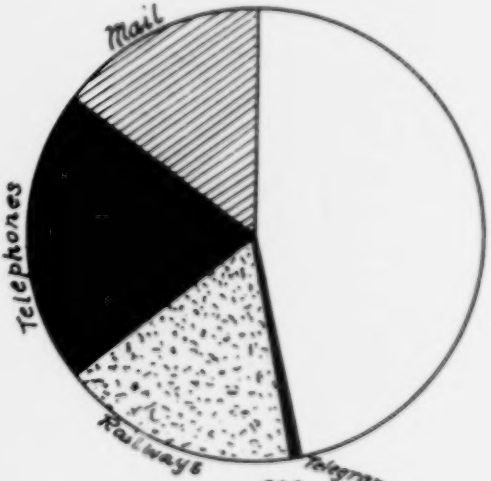

Growth of Population and Business
New York City.
P = Population
L = LETTERS
R = Railroad Passengers
T = Telephone Calls
Tg = Telegraphs
5mill
4mill
3mill
2mill
1mill
P.L.R.T.Tg.
P.L.R.T.Tg.
P.L.R.T.Tg.
1890
1900
1910
Ex. 210

Increase Business Pressure per Capita N.Y. City in 20 Years.

Chart No. 6
Charles E. Read, Del.

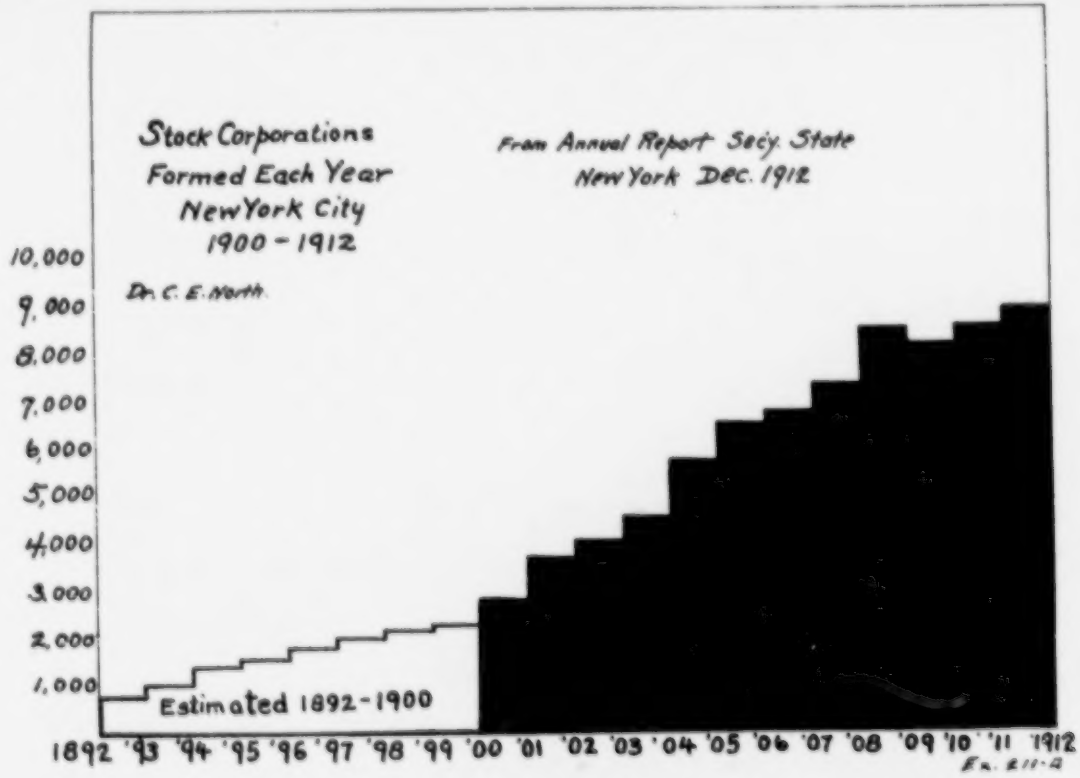


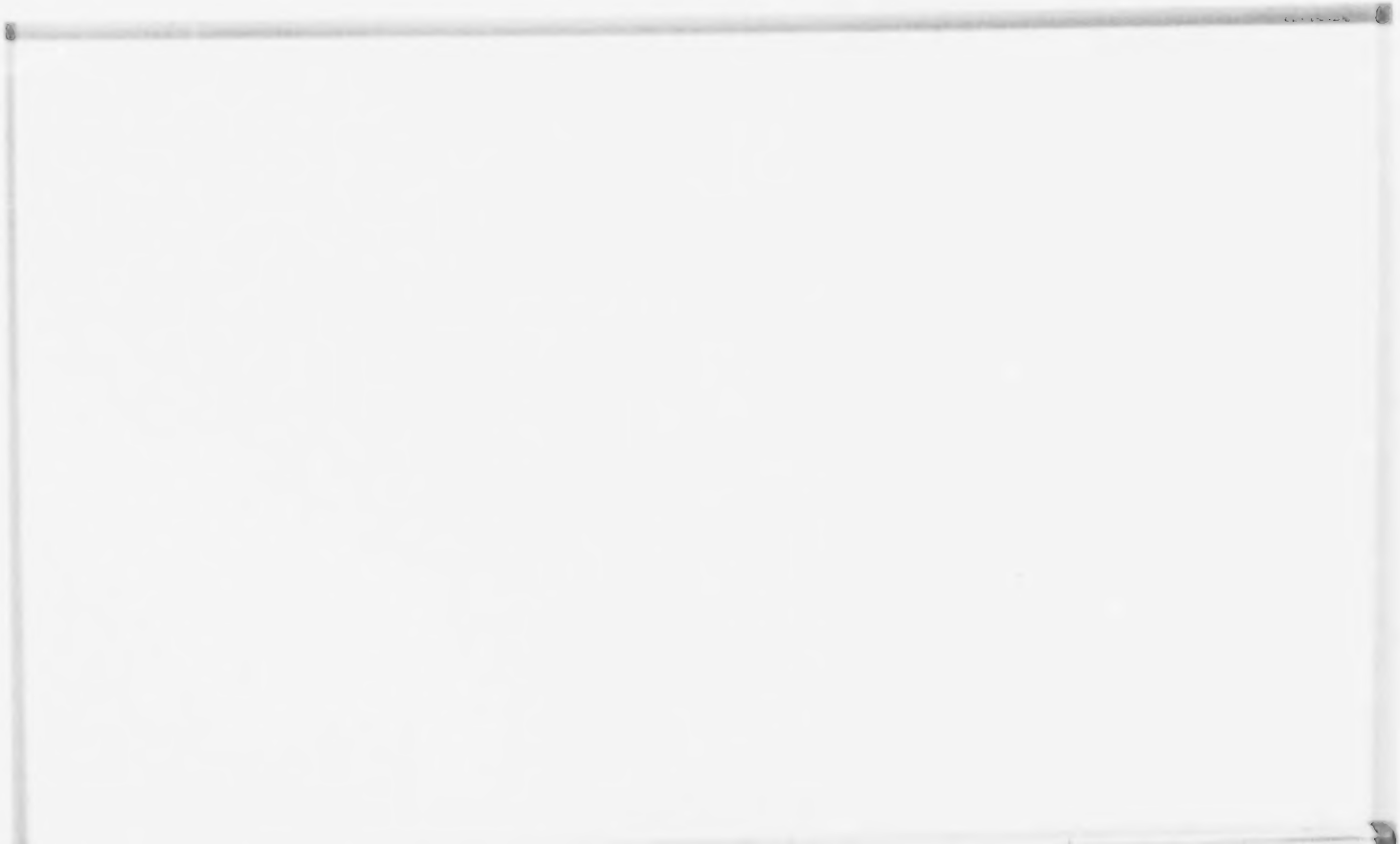
1890.
391.64 Transactions

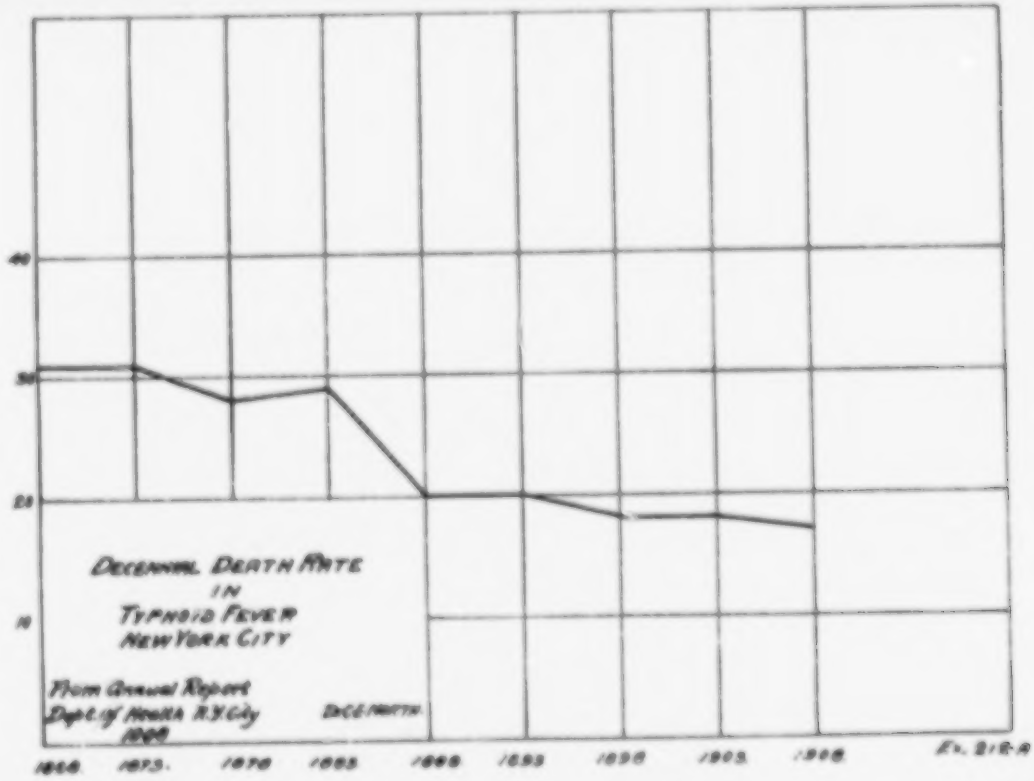


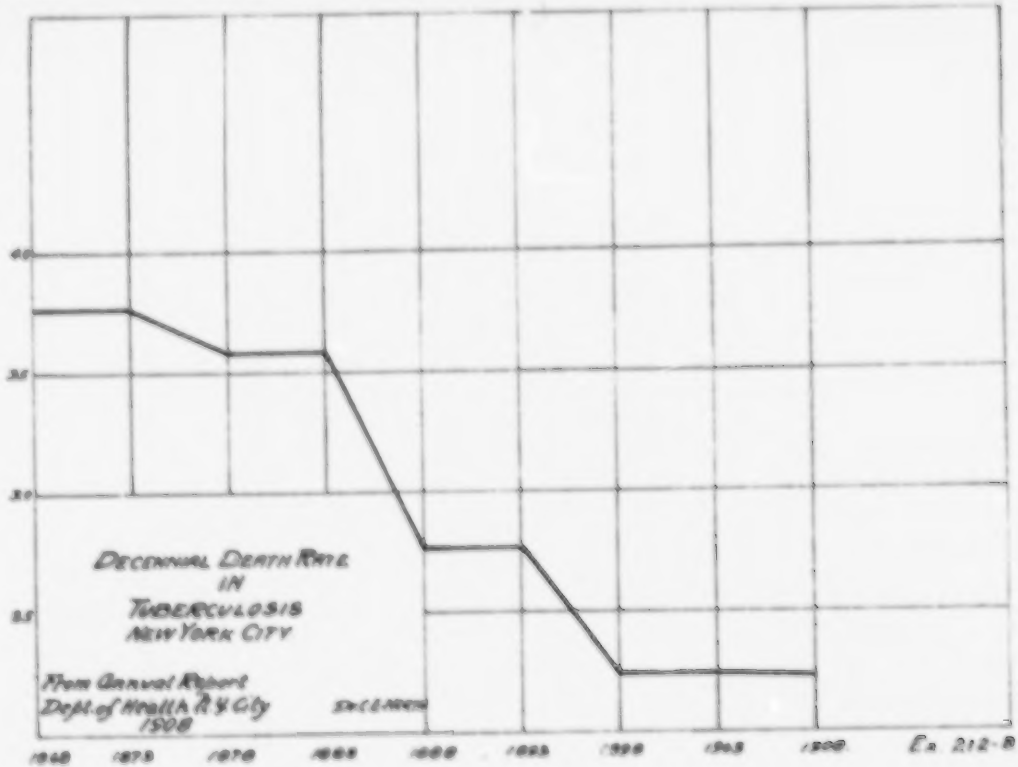
1900
965.15 Transactions

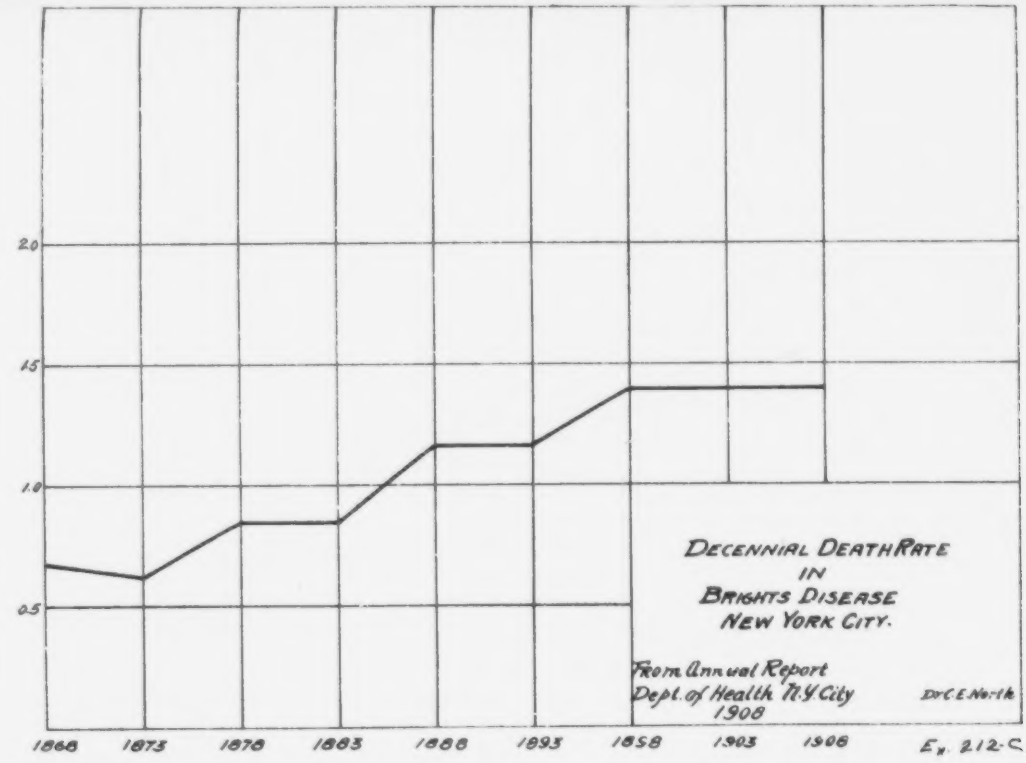
Ex. 211

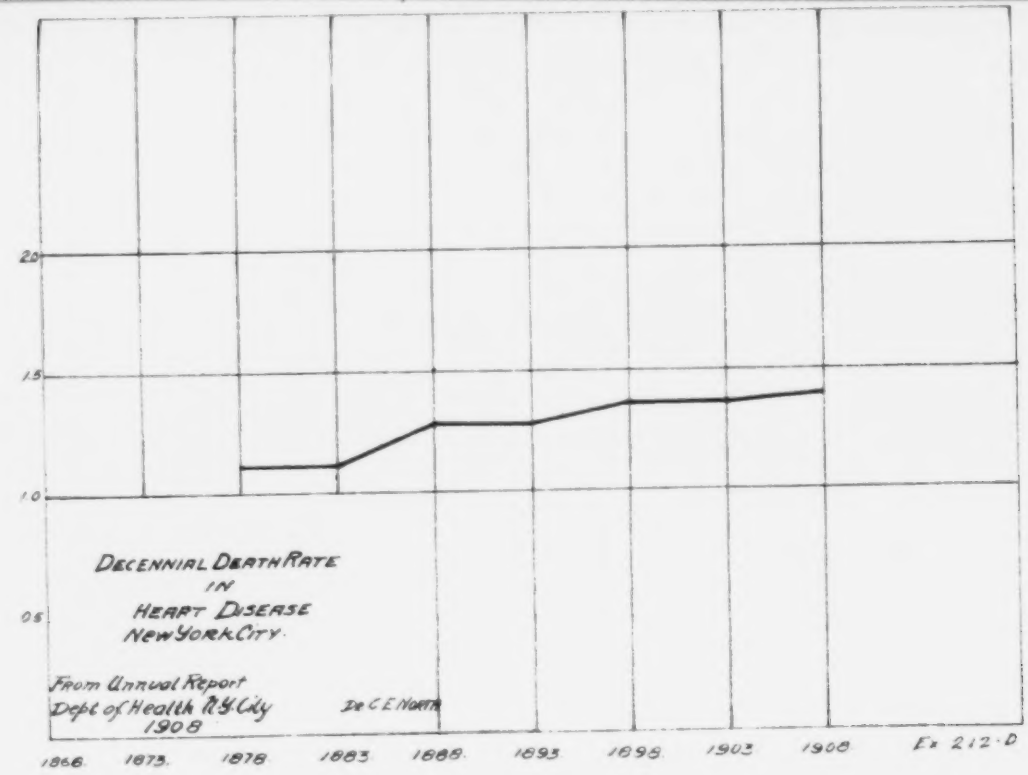

Stock Corporations
Formed Each Year
New York City
1900 - 1912
Dr. C. E. North.
From Annual Report Secy. State
New York Dec. 1912
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
Estimated 1892-1900
1892 '93 '94 '95 '96 '97 '98 '99 '00 '01 '02 '03 '04 '05 '06 '07 '08 '09 '10 '11 1912
Ex. 211-A

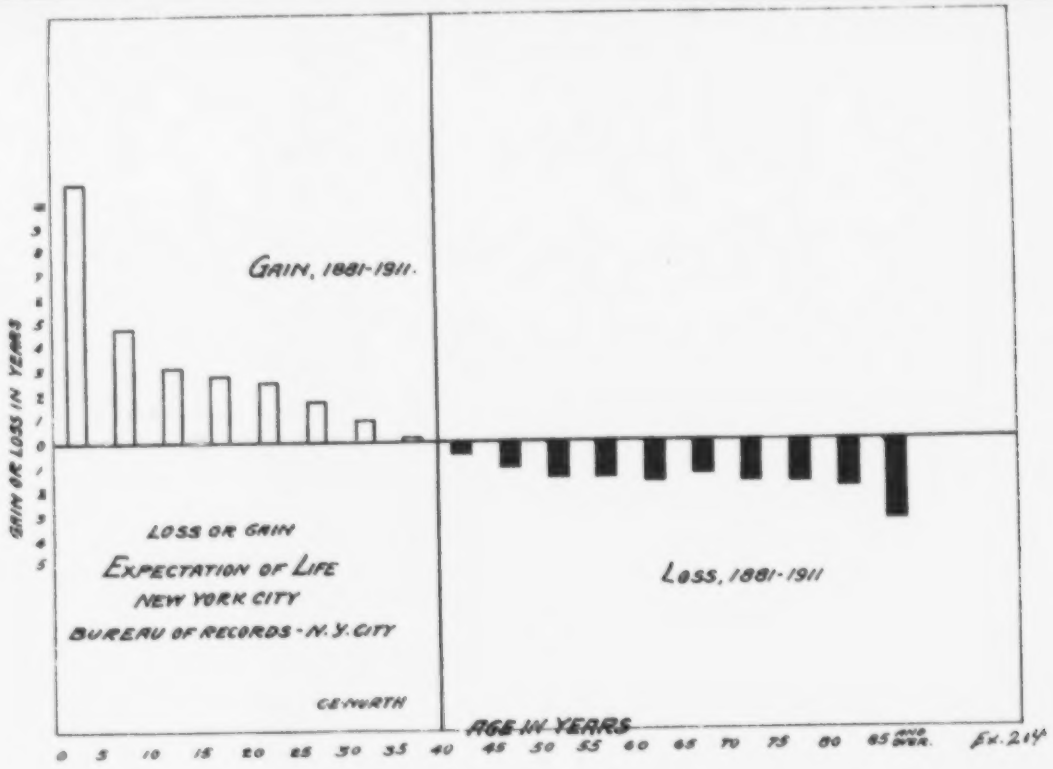


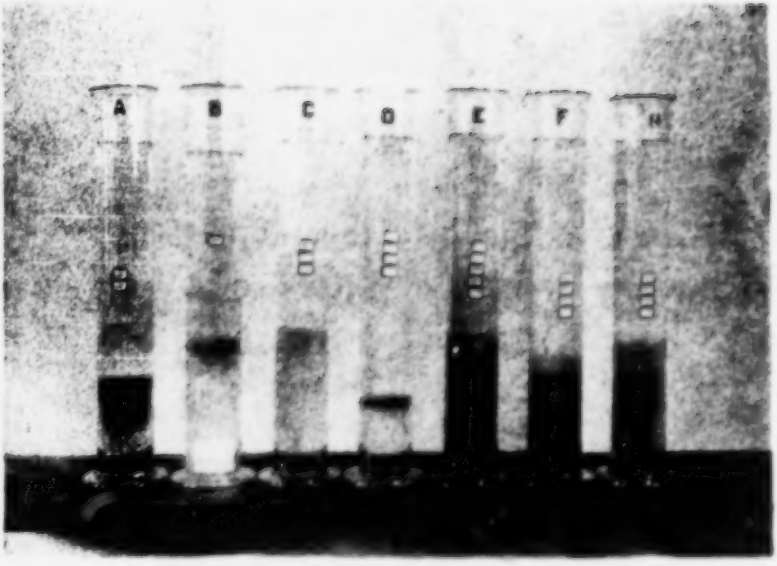

40
30
20
10
DECENNIAL DEATH RATE
IN
TYPHOID FEVER
NEW YORK CITY
From Annual Report
Dept. of Health N.Y. City
1909
DECENNIUM
1860
1870
1880
1890
1900
Fig. 212-A


40
35
30
25
DECENNIAL DEATH RATE
IN
TUBERCULOSIS
NEW YORK CITY
From Annual Report
Dept. of Health N.Y. City
1908
1860
1870
1880
1890
1900
Ex. 212-B


2.0
1.5
1.0
0.5
1868
1873
1878
1883
1888
1893
1898
1903
1908
Ex. 212-C.
DECENNIAL DEATH RATE
IN
BRIGHTS DISEASE
NEW YORK CITY.
From Annual Report
Dept. of Health N.Y. City
1908
Dr C.E. North


2.0
1.5
1.0
.05
DECENNIAL DEATH RATE
IN
HEART DISEASE
NEW YORK CITY.
From Annual Report
Dept of Health N.Y. City
1908
Dr C.E North
1868.
1873.
1878.
1883.
1888.
1893.
1898.
1903.
1908.
Ex 212-D


GAIN, 1881-1911.
LOSS, 1881-1911
GAIN OR LOSS IN YEARS
0 1 2 3 4 5 6 7 8
5 4 3 2 1 0
LOSS OR GAIN
EXPECTATION OF LIFE
NEW YORK CITY
BUREAU OF RECORDS - N.Y. CITY
C.E. NORTH
AGE IN YEARS
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 AND OVER.
EX. 214



(Exhibit 215 - page 3)

1 COMPLAINANTS' EXHIBIT No. 215. James D. Maher, Commissioner.

Effect of Salinity and Direction of Discharge on the Ascent of Fresh Water in Salt Water.

Edward Ellery.

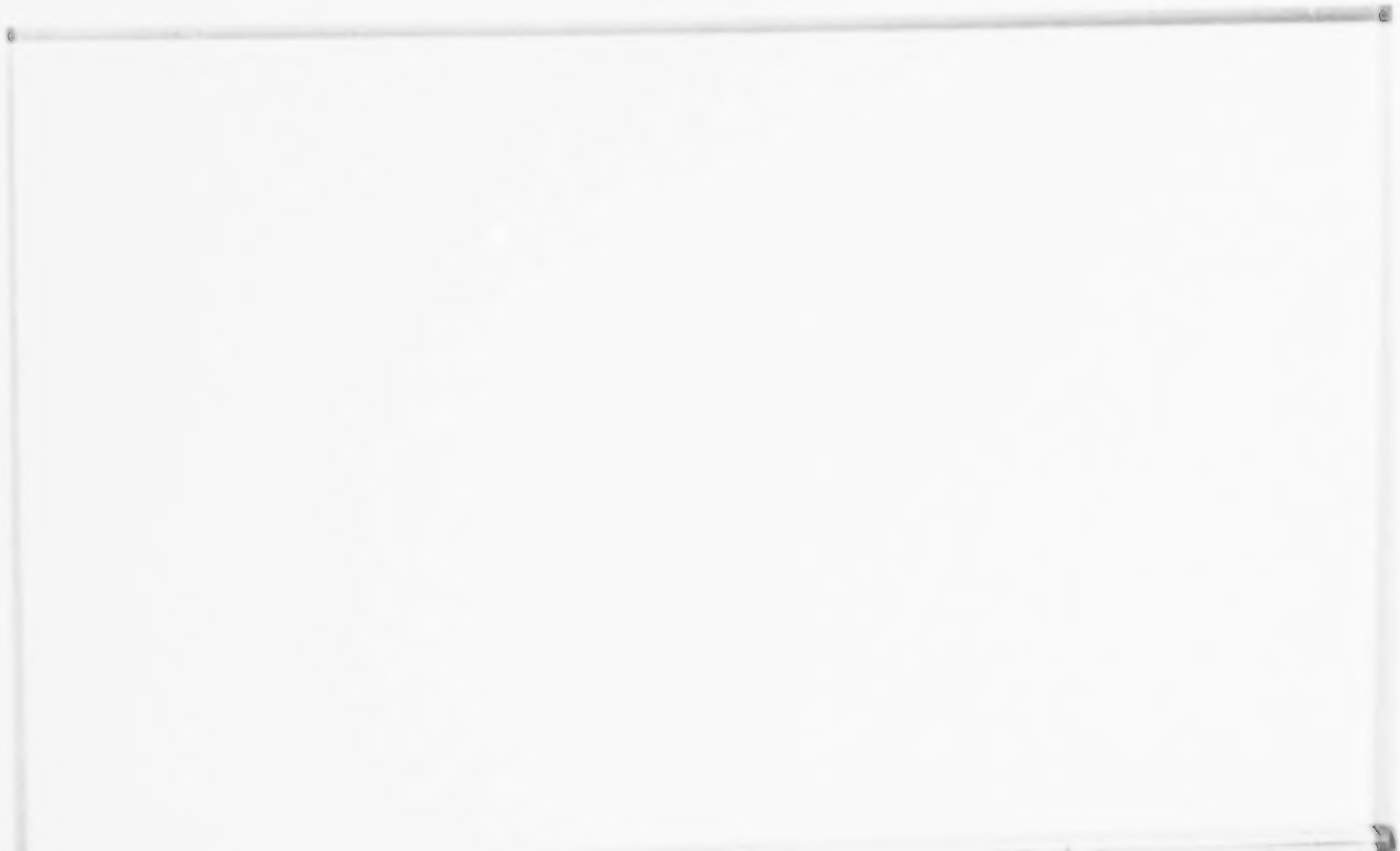
---

2 COMPLAINANTS' EXHIBIT No. 215. James D. Maher, Commissioner.

Effect of Salinity and Direction of Discharge on the Ascent of Fresh Water in Salt Water.

Edward Ellery.

(Here follows diagram showing ascent of fresh water in salt water, marked Exhibit 215, page 3.)



Cylinder "A." Water of 14,019 parts Chlorine per million under fresh water. Dye solution delivered in lower layer in upward direction. After ten days standing.

Cylinder "B." Water of 14,019 parts Chlorine per million under water of 7,009 parts Chlorine per million. Dye solution delivered in lower layer in upward direction. After ten days standing.

Cylinder "C." Water of 6,754 parts Chlorine per million under water 3,377 parts per million. Dye delivered in lower layer in upward direction. After ten days standing.

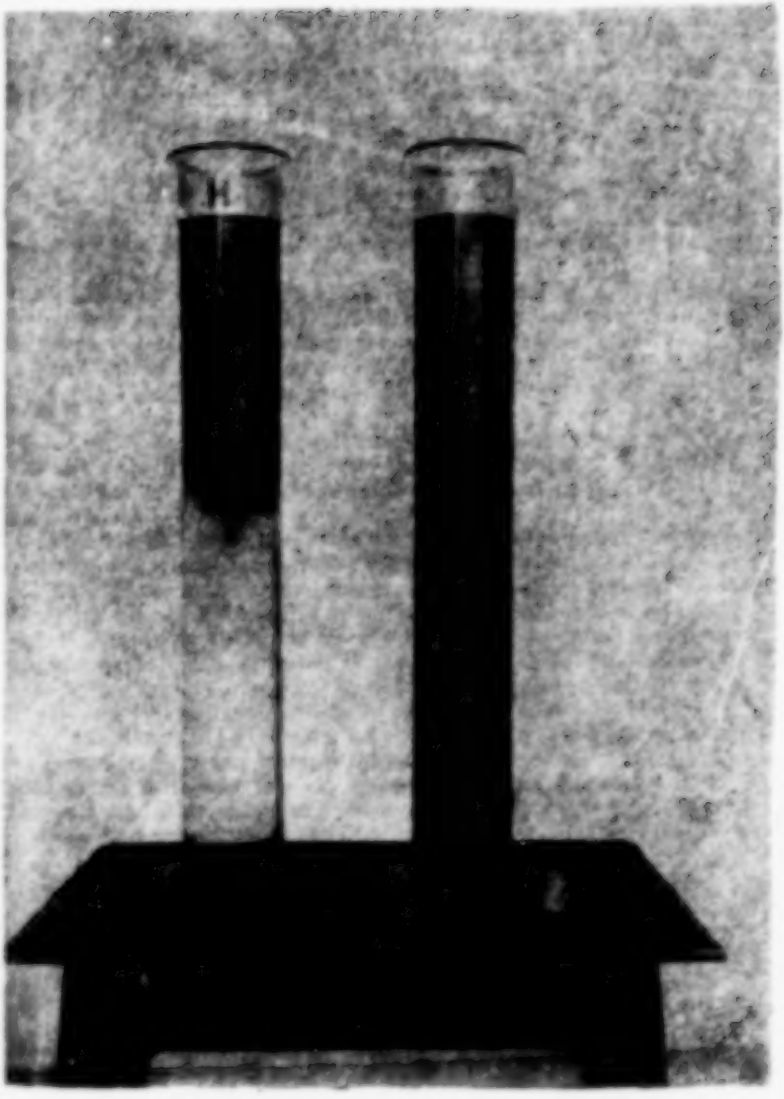
Cylinder "D." Water of 8,500 parts Chlorine per million under water of 6,500 parts per million. Dye solution delivered in lower layer in upward direction. After three days standing.

Cylinder "E." Water of 8,500 parts Chlorine per million under water of 8,000 parts per million. Dye solution delivered in lower layer in downward direction. After two days standing.

Cylinder "F." Water of 8,500 parts Chlorine per million under water of 7,500 parts per million. Dye solution delivered downward, in lower layer. After two days standing.

Cylinder "G." Water of 8,500 parts Chlorine per million under water of 7,000 parts per million. Dye solution delivered in downward direction in lower layer. After two days standing.

(Here follows diagram marked Exhibit 215, page 5.)



(Enclosed 215, page 5)

6 Cylinder "H." Water of 8,500 parts Chlorine per million. Dye solution delivered about eight inches from the bottom, in an upward direction. After two hours standing.

Cylinder with no letter shows how the waters looked when the dye solution had diffused itself throughout the entire column.

7 *Foreword.*

In his testimony in the case of New York vs. New Jersey and The Passaic Valley Sewerage Commission, Mr. Geo. A. Johnson, witness for the defendant, testified as follows, regarding a certain dye experiment performed by him:

1. 30,000 gallons of water heavily charged with an aniline dye were pumped into the bay, 10, 20, 30, and 40 feet below the surface at rates varying from 1.8 to 2 cu. ft. per second (pages 3976-77).

2. Strength of dye solution was 2/3 of a pound to 1,000 gallons of water, or about 1 part dye in 11,500 parts water by weight (page 3977).

3. The discharge pipe pointed vertically downward (page 3997).

4. At the hour of discharge into the deepest water both surface and bottom currents were of the same velocity and in the same direction (pages 3978-3982).

5. The salinity of the water was 8,500 parts Chlorine per million, about 46% sea water (page 3979-3982).

6. The inference is drawn that when fresh water sewage, discharged as proposed through outlets, some 150 in number, and located at a depth of 40 ft., or more below the surface, will undergo a sufficiently complete diffusion in the waters of New York Bay so as not to rise to the surface in objectionable quantities if at all, and rarely if at all in visible quantities" (page 3982-3983).

The following study shows what conditions must be taken into consideration before any interpretation can be made of the results of discharging fresh water into salt water, and in the absence of such details in Mr. Johnson's testimony regarding his experiment
8 he had no sufficient basis for his inference, and further his inference is erroneous.

Outline of the Experiments.

I. Effect of direction of discharge of fresh water into salt waters when the latter is of the same degree of salinity throughout.

II. Effect of delivering fresh water in an upward direction into salt water consisting of layers of different degrees of salinity.

III. Effect of delivering fresh water in a downward direction into salt water consisting of layers of different degrees of salinity.

General Conclusions.

1. When fresh water is discharged in a downward direction into salt water of the same degree of salinity throughout, it first continues to move downward and then moves upward to the surface.

2. When fresh water is discharged sidewise into salt water of the same degree of salinity throughout, it rises to the surface at once.

3. When fresh water is discharged in an upward direction into salt water of the same degree of salinity throughout it rises to the surface at a more rapid rate that in either case 1 or 2.

4. When fresh water is discharged in an upward direction into salt water consisting of different layers of varying degrees of salinity, it comes to the surface at once, except in cases of large difference in salinity of the layers.

5. When fresh water is discharged in a downward direction into salt water consisting of layers of different degrees of salinity, it rises only to the top of the lower layer and remains there for periods of time varying from two to ten days.

6. Therefore the question of whether fresh water discharged into salt water will come to the surface or not, depends on two conditions; first, the direction of discharge, and second, difference in salinity in different layers of the water into which the discharge takes place.

Apparatus Used in the Study.

For the purposes of this study tall cylinders were used 28 inches high and 4 inches in diameter. These were filled with 4 liters of water. To the water varying amounts of salt accurately weighed were added, and thoroughly mixed to insure the homogeneity of the solution. In the cases in which different layers of water were required in the same cylinder, the heavier water was delivered at the bottom of a lighter water by means of an elongated funnel tube reaching to the bottom of the cylinder.

For delivering the dye solution three long glass tubes were used of the same calibre, one straight throughout its length for delivery in a downward direction, one with a bend at right angle for delivery sidewise, and one with the end bent to deliver the solution in an upward direction. These tubes were graduated in order that the same amount of dye solution might be delivered at each trial and at the same velocity.

Two dyes were used, one known as "Special Scarlet", referred to by the Metropolitan Sewerage Commission in its report for 1910, page 458, and one known as "Red 2R", presumably the one referred to by Mr. Johnson in his testimony (page 3977). These are azo-dyes of similar chemical structure, are both soluble in water to a deep red solution, and both give easily distinguishable color in extremely dilute solutions.

The strength of the solution in each case was eighty parts of dye to a million parts of water, or in other words one part to 12.500, the strength Mr. Johnson used in his experiment (page 3977-3978).

Results of the Series.

I.

Conditions: Homogeneous solution.
Delivery down, sidewise and up.
Time noted when color reached the surface.

Salinity parts chlorine per million.	Delivered down.	Delivered sidewise.	Delivered up.
6,754	Less than 5 min.	Less than 5 min.	Less than 5 min.
7,098	" "	" "	" "
7,266	" "	" "	" "
8,055	" "	" "	" "
9,006	" "	" "	" "
9,590	" "	" "	" "
10,009	" "	" "	" "
13,062	" "	" "	" "
13,703	" "	" "	" "
14,500	" "	" "	" "
16,098	" "	" "	" "
17,098	" "	" "	" "

11 *Conclusion.*

When delivered into salt water varying in salinity from 6,754 parts chlorine per million (36.5% sea water) to 17,098 parts chlorine per million (96.5% sea water) fresh water rises at once to the surface, and the direction of the discharge does not make any further difference than to affect the rate of rise.

II.

Conditions: Two layers, salt water, of different degrees of salinity.
Delivery in upward direction.

For this series cylinders were prepared as follows:

1. Water of 14,019 parts Chlorine per million under fresh water Cylinder "A" of the photograph.

2. Water of 14,019 parts Chlorine per million under water of 7,009 parts Chlorine per million.
Cylinder "B" of the photograph.

3. Water of 6,754 parts Chlorine per million under water of 3,377 parts Chlorine per million.
Cylinder "C" of the photograph.

4. Water of 8,500 parts Chlorine per million under water of 8,000 parts Chlorine per million.

5. Water of 8,500 parts Chlorine per million under water of 7,500 parts Chlorine per million.

6. Water of 8,500 parts Chlorine per million under water of 7,000 parts Chlorine per million.
7. Water of 8,500 parts Chlorine per million under water of 6,500 parts Chlorine per million.
Cylinder "D" of the photograph.

12 *Results.*

1. No color in the upper layer after ten days. All in lower layer.
2. No color in upper layer after ten days. Color diffused through lower layer but most of it at the junction on the two layers.
3. No color in the upper layer, after ten days. Color evenly diffused through lower layer.
4. Color reached the surface in less than five minutes.
5. Some color reached the top in less than five minutes, but heavy line of color was noticeable between the layers after an hour.
6. Some color reached the top in less than five minutes, but heavy line of color was noticeable between the layers after two hours.
7. No color had reached the top after three days.
The photograph shows these results very distinctly and the sharp line of division between the different layers.

Conclusion.

Fresh water delivered upward at the velocity of these experiments in the lower of two layers of salt water of different degrees of salinity, does not rise to the surface if the difference in salinity is 11% or more.

III.

Conditions: Two layers, salt water, of different degrees of salinity. Delivery in downward direction.

In this series a blank determination was first made with five cylinders of water of different degrees of salinity, starting with a water containing 8,500 parts chlorine per million, the salinity observed by Mr. Johnson at the time of his experiment (pages 3979-3982).

13 The following results were noted:

Salinity parts chlorine per million.	Dye solution delivered downward.
8,500	Reached the surface in less than five minutes.
8,000	" " " " " " " "
7,500	" " " " " " " "
7,000	" " " " " " " "
6,500	" " " " " " " "

Cylinders were then prepared as follows:

1. Water of 8,500 parts Chlorine per million under water of 8,000 parts per million.

Cylinder "E" of photograph.

2. Water of 8,500 parts Chlorine per million under water of 7,500 parts per million.

Cylinder "F" of photograph.

3. Water of 8,500 parts Chlorine per million under water of 7,000 parts per million.

Cylinder "G" of photograph.

4. Water of 8,500 parts Chlorine per million under water of 6,500 parts per million.

The dye solution was delivered downward as in the blank in the bottom layer of each cylinder, with the following results, shown very clearly in the photograph:

1. Distinct stratification as shown by the color in the lower layer after 48 hours.
2. Ditto.
3. Ditto.
4. Ditto.

After six days the stratification was still distinct in "4" but the color had diffused in that time throughout the *the* others.

14 *Conclusion.*

When fresh water is delivered downward in salt water consisting of layers of different degrees of salinity, a very slight difference in salinity (less than three per cent) is sufficient to keep the fresh water in the lower layer although the same fresh water will rise through *through* either layer alone.

General Conclusions from I, II, and III.

It is apparent from the foregoing that direction of discharge and salinity in different layers of water into which the discharge takes place determine whether the discharged water will come to the surface or not. It seems therefore that Mr. Johnson's inference, if based upon the data given in his testimony (pages 3976-4011) and on no other, is not warranted and is untenable. It is doubtless true that under some circumstances fresh water when delivered downward into salt water will not come to the surface, but it is equally true that under other circumstances it will come to the surface. A general statement that it will or that it will not come to the surface can not be made.

It is further to be noted that in Mr. Johnson's experiment the fresh water was delivered in a downward direction while in the proposed plan of the defendant the sewage is to be delivered upward. These experiments, herein recorded, show that when fresh water is delivered upward in salt water there are fewer conditions which prevent its coming to the surface than under any other method

of delivery. A conclusion based upon the result of delivering
15 fresh water downward into salt water is not applicable to the condition when the fresh water is delivered upward.

The differences in salinity of the layers of water off Robbins Reef are very clearly shown in the report of the Metropolitan Sewerage Commission for 1910 on page 527. "The difference between the salinity of the water at the surface and at a depth below the surface of 40 ft. was found more marked at Robbins Reef than at most other places, the surface sometimes containing 10% more land water than that near the bottom, but this condition was variable". The table of salinities given on that page of the report shows that the difference of salinity would be great enough at times to keep fresh water delivered in the lower depths downward in that stratum, but would not be great enough to keep the fresh water in the lower stratum if it were delivered upward. The report also shows on the same page that there are times when the conditions are such that the fresh water would come to the surface, whatever the direction of its discharge. The report states—

"A sample taken at Robbins Reef October 30 at 4 P. M. had a specific gravity of 1.025, indicating an entire absence of land water."

This study shows that under those circumstances or any others in which there was homogeneity in the waters fresh water will come to the surface whatever the direction of discharge.

These considerations show that Mr. Johnson did not have sufficient basis for his inference, or having it failed to give it in his testimony. They further show that whether he had more data than he gave or not his inference is erroneous.

a COMPLAINANTS' EXHIBIT No. 216. James D. Maher, Commissioner.

THE AERATION OF WATER.

Special Topic: The Influence of Sewage Pollution.

Edward Ellery.

---

1 COMPLAINANTS' EXHIBIT No. 216. James D. Maher, Commissioner.

THE AERATION OF WATER.

Special Topic: The Influence of Sewage Pollution.

Edward Ellery.

2 *Foreword.*

This study of the influences that affect the rate of absorption by water of oxygen from the atmosphere is not undertaken to determine with scientific accuracy the coefficient of oxygen absorption, but is being carried on with a view to determining what actually takes place in the matter of oxygen absorption under varying conditions. The plan is to study two large volumes of water at the same time and, if possible, to change one of the variables while keeping all the others constant. It is thought that such a study will throw some light on the complex problem of aeration of water from the atmosphere.

The special topic herein treated, namely, "The Influence of Sewage Pollution," is taken up at this time under the direction of Dr. W. J. O'Sullivan, Special Counsel for New York in the case of New York vs. New Jersey and the Passaic Valley Sewerage Commission, and the results are the property of New York, to be used only as counsel in the above case may permit and direct.

General Conclusions.

1. Salt water of from 60% to 70% of the salinity of the sea water seems to absorb oxygen from the air at practically the same rate as fresh water, between the points of 40% and 60% of saturation for each. (See General Conclusions, Series I, pages 11, 12).

3 2. The absorption of oxygen by both fresh and salt water from the air is not so rapid as has been supposed. Dr. Adeney's maximum of 0.067 c. c. to 0.077 c. c. of oxygen per liter per hour seems high in the light of this study. These experiments show that the rate of absorption may vary from 0.18 c. c. per day to 0.306 c. c. per day in quiescent water and to 0.515 c. c. per day in moving water. (See General Conclusions, Series I, Page 12).

3. Whatever may be the cause of fluctuations in the amount of oxygen absorbed, it affects both fresh and salt water in the same way. (See diagram I.)

4. The greater the humidity, the less is the rate of absorption of oxygen by both fresh and salt waters. (See diagram II, III and V. Also Results, Series IIA, page 13). (Also Results, Series IIIA, Page 18.)

5. Polluted salt water absorbs oxygen at a greater rate than unpolluted. (See Results, Series IIA, pages 13; Results Series IIB, page 16; Results IIIA, page 18; Exception in the case of the second day, Series IIIA, page 18).

6. A dilution of the proportion of one part of sewage to sixty (60) parts of salt water, when the water is quiescent, does not seem permissible, while a dilution of 1:100 does not show reduction of oxygen content below the initial content. (See Diagrams IV and VII; Results Series IIA, page 14; Results Series IIB, page 16.)

7. The average rate of absorption of oxygen by quiescent salt water may run as high as 0.306 c. c. per day, and of salt water moving at the rate of one foot per second, as high as 0.515 c. c. per day. (See Conclusions, Series IIB, page 16; Results, Series IIIA page 18).

4

8. Salt water moving at the rate of one foot per second seems to be able to take care of sewage in the dilution of 1:60 and possible even the dilution of 1:30. (See Results, Series IIIB, page 20; Conclusions, Series IIIA, page 19.)

9. Salt water whose oxygen content has been reduced to 3 c. c. oxygen per liter (Eddy's Standard) if quiescent will not take care of sewage discharge into it at the rate of one gallon of sewage to 60 gallons of water, but seeme to be able to take care of the sewage discharged into it at the rate of one gallon of sewage to 100 gallons of water.

10. Moving salt water, containing 4.526 c. c. of oxygen per liter, seems to be able to take sewage in the proportion of 1:30 without diminution of oxygen content below 4.294 c. c.

11. The sewage disposal capacity of moving salt water seems large, if the sewage can be evenly distributed throughout its volume.

For this part of the study, waters were examined as follows:

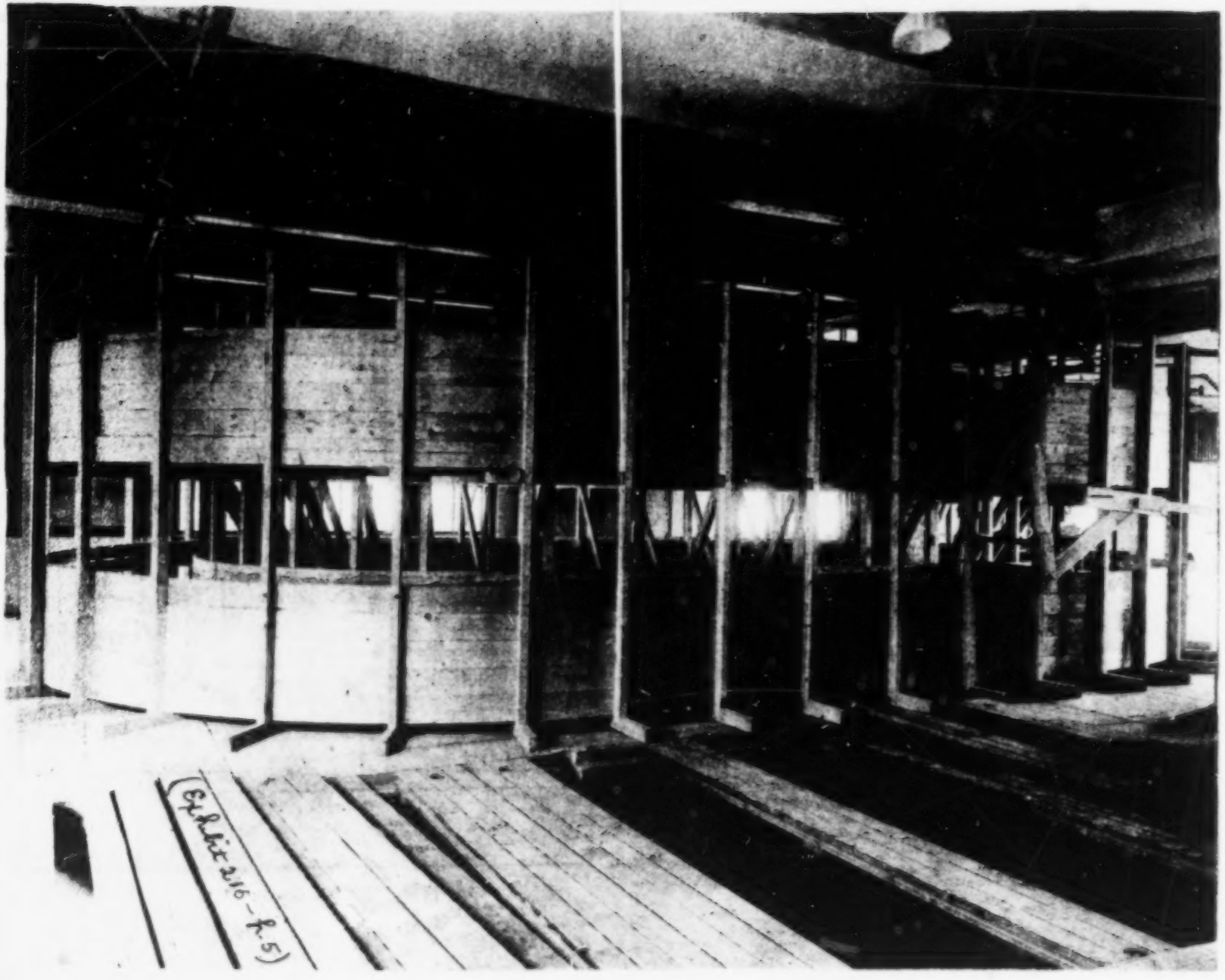
I. Fresh and Salt Water.

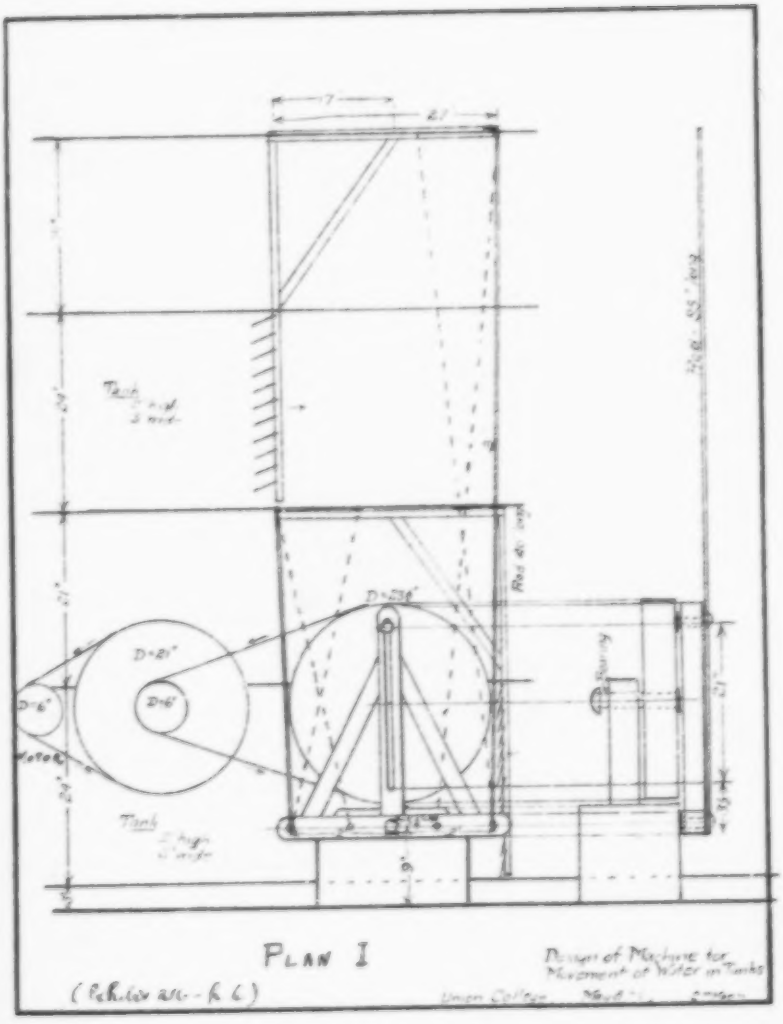
II. Polluted and Unpolluted Quiescent Waters, with two degrees of pollution.

III. Polluted and Unpolluted Moving Waters, with two degrees of pollution.

This work involved a total of 700 oxygen determinations.

(Here follow two diagrams marked Exhibit 216, pages 5 and 6.)


Exhibit 216-F-5)



PLAN I

Design of Machine for Movement of Water in Tanks

(Parker and K C)

Union College



7 *The Apparatus.*

Two elliptical tanks, built one above the other as shown in the accompanying photograph, are used to contain the water under examination. The curved ends are semicircles of 7½ foot radius and the straight sides are 13 feet long. The width of the tanks is 3 feet and the depth of the water 2 feet. The cubical content of each tank is therefore 438.74 cubic feet, or 3,282 gallons.

The apparatus for keeping the water in motion, the levers of which are shown at the right of the photograph, was devised by Professor O. H. Landreth, to whom the grateful appreciation of the author is heartily given for his constant and valuable advice and supervision of the work. The details of the apparatus are shown in Plan I. Each tank is provided with a wing, extending across the entire width, which consists of a frame and shutters, so constructed that at the forward movement the shutters are closed, thus pushing the water ahead, and at the return movement are open, thus offering little resistance to the water. By swinging these wings backward and forward, the water is given a flowing motion around the tank, and, as the shutters are entirely immersed in the water, all aeration due to spattering is avoided.

Plan I also shows the propelling device. The wing of the upper tank is attached by a long arm to the right extremity of the "T", and that of the lower tank by a shorter arm to the left extremity of the "T". The "T" is provided with a slot in which the button
8 attached to the wheel moves up and down with each revolution of the wheel, thus giving the cross-arm of the "T" a motion similar to the walking beam of a steamer, and causing the wings to swing back and forth. The whole is attached by an intermediate shaft to a motor. The dotted lines in the plan show how, by attaching the rods at different places on the "T" and on the arms of the wings, different rates of velocity are obtained.

Owing to circumstances not under our control, the electric motor intended for use as a propelling power was not delivered at our laboratory in time to be available for this series of observations, and we were compelled to resort to hand power. This was placed at the end of the long lever shown in the photograph between the two tanks, and the wings were attached to each other by one long arm. The velocity of the water around the tank was measured at intervals, and it is believed the average thus obtained represents the real velocity of the water during the days on which observations on moving water were taken.

The object of having two tanks is obvious. With one containing salt water and the other fresh water, for instance, whatever the atmospheric conditions, both will be under the same conditions and subject alike to whatever change may take place in these conditions during any period of observation. As to the size of the tanks, it is our desire to study as large a volume of water as our facilities allow, and the apparatus was set up in the Hydraulic Laboratory of the General Engineering Building of Union College.

9 Humidity measurements were made by means of an improved form of Hygrodeik manufactured by the Taylor Instrument Company of Rochester, N. Y. It consists of two thermometers (wet and dry bulb) mounted on the outer edges of a chart, plotted from new and corrected tables prepared under the direction of the United States Weather Bureau.

Temperatures were read from accurate chemical thermometers, in Centigrade degrees. The thermometeres were suspended in and over the waters in each tank. For the convenience of those who are not accustomed to the Centigrade scale, the temperature readings are given in the tables as Fahrenheit degrees. It will be at once apparent from those readings that our experiments were conducted under summer conditions.

Atmospheric pressure was read from the ordinary mercury column barometer, graduated to give accurate readings to 1/100 of an inch.

10 *Methods of Operation.*

Each series of observations was begun by filling the tanks with water to within three or four inches of the top. When salt water was to be used, a measured quantity of salt was added. Live steam was led into the water until the temperature stood at about 60 degrees Centigrade. The valve controlling the steam jets is shown in the right of the photograph, just above the upper tank. The rate of absorption of oxygen by quiescent water is so slow that, by the time the water had cooled to room temperature, when observations were begun, a condition of 50% to 60% saturation was easily obtainable by this method. At the time of the last series, the college steam plant was not in operation, and advantage was taken in this case of the fact that the Schenectady water runs low in dissolved oxygen. It will be seen that that set of observations does not have so low a starting point as the previous ones.

Sewage for polluting the waters was taken from one of the manholes of the city sewers, just outside one of the entrances to the Union College grounds. Sewers come to this manhole from three directions, but all of them from residential portions of the city. The sewage used in these experiments was, therefore, entirely free from factory or trade wastes. Samples were collected between 7 A. M. and 8 A. M. in each instance, a period when the flow past this special manhole is larger than at any other hour of the day.

11 The method of determining dissolved oxygen used for these experiments was the so-called Lævy Method, which investigation in this laboratory in 1912 showed to be more dependable than other well known methods, when water contains a large amount of nitrites. The reagents are as follows:

Ferrous Sulfate:

144 grams Kohlbaum's crystallized ferrous sulfate, 15 c. c. concentrated sulfuric acid, and 3 liters of water.

Sodium Carbonate:

100 grams in 1 liter of water.

Sulfuric Acid:

Equal parts of concentrated acid and water Potassium Permanganate.

25.4 grams to 4½ liters of water.

This reagent was standardized against Sodium Oxalate obtained from the Bureau of Standards, Washington, D. C.

In place of the usual pipettes, burettes especially designed by this laboratory and made by Emil Greiner Company, New York, were used for measuring the reagents. The burettes were calibrated in accordance with the regulation of the United States Bureau of Standards.

The sampling bottles were of about 500 c. c. capacity, and three samples were taken for every determination, one for a blank and one for a check. The samples were drawn from "midstream" and at the middle depth. A siphon of small glass tubing was
12 used for the purpose, and was securely fastened in place in each tank, to insure a sample from the same point for each determination.

13 *Outline of Plan of Observation.*

I. A study of salt and fresh quiescent water.

II. A study of polluted and unpolluted quiescent salt water, with varying degrees of pollution.

III. A study of polluted and unpolluted, moving salt water with varying degrees of pollution.

Series I.

Comparison of Unpolluted, Quiescent Fresh and Salt Water.

For this series, the upper tank was filled with fresh water and the lower tank with the same water to which salt was added sufficient to give a salinity of 11,341.6 parts chlorine per million, or a little in excess of 60% of the salinity of sea water. The series ran through seven days, Sunday intervening, on which no determinations were made. The first day, samples were taken every hour, but the rate of absorption proved to be so slow that throughout the succeeding days samples were taken at intervals of three hours.

In this series as in all the others, air and water temperatures, humidity and barometer readings were taken with each sample. These readings are recorded in Table I. The curves for the amount of oxygen per liter are given in Diagram I, and a comparison of Oxygen and Humidity curves for both waters are given in Diagrams II and III.

14 TABLE I.

Oxygen Absorption by Fresh and Salt Waters Under the Same Conditions.

Salt. c. c. oxygen per l.	Fresh.	Time.	Humidity, %	Barometer, in.	Temp. air.	Temp. water.
2.439	.....	11 A. M., Sat.....	48.5	29.85	72.5	71.6
.....	2.867	"	"	"	74.	71.
2.666	.....	12 M.	39	"	71.6	72.5
.....	2.714	"	"	"	73.	71.
2.666	.....	1 P. M.	37.5	"	71.6	72.5
.....	2.641	"	"	"	73.4	69.8
2.666	.....	2 P. M.	44	"	74.	71.6
.....	2.993	"	"	"	74.	69.8
2.714	.....	3 P. M.	45	29.86	71.6	72.5
.....	2.791	"	"	"	73.4	69.8
2.528	.....	4 P. M.	46	29.84	71.	71.6
.....	2.917	"	"	"	72.5	69.8
2.791	.....	5 P. M.	44	"	69.8	71.6
.....	2.703	"	"	"	72.5	69.8
4.049	.....	11 A. M. Mon.....	49	"	71.	64.4
.....	3.373	"	"	"	72.5	66.2
3.514	.....	4 P. M.	55.5	"	64.4	64.4
.....	3.513	"	"	"	66.2	67.
3.658	.....	8 A. M. Tues.....	47	30.13	67.	62.6
.....	3.731	"	"	"	71.	64.4
3.810	.....	11 A. M.	43	30.03	71.6	64.6
.....	3.986	11 A. M.	43	"	73.4	65.5
3.963	.....	2 P. M.	34	30.02	72.5	64.4
.....	3.782	"	"	"	75.2	66.2
3.785	.....	5 P. M.	39.5	30.04	73.4	64.4
.....	3.782	"	"	"	75.2	66.2
3.799	.....	8 A. M. Weds.....	37.5	30.22	69.	64.
.....	4.119	"	"	"	72.5	66.2
4.074	.....	11 A. M.	"	"	71.6	65.5
.....	4.707(?)	"	"	"	74.5	66.2
3.947	.....	2 P. M.	37.5	"	73.4	64.4
.....	4.094	"	"	"	77.	67.
4.049	.....	5 P. M.	41.5	30.24	69.	64.4
.....	4.042	"	"	"	72.5	67.
3.908	.....	8 A. M. Thursday..	40.5	30.34	69.8	64.
.....	3.698	"	"	"	72.5	66.2
4.048	.....	11 A. M.	"	30.33	73.4	64.4
.....	4.098	"	"	"	76.	67.
4.393	.....	2 P. M.	36.5	30.29	73.4	64.4
.....	3.946	"	"	"	75.2	68.
4.196	.....	5 P. M.	38.5	30.23	69.8	64.4
.....	3.698	"	"	"	72.5	68.
3.727	.....	8 A. M. Friday.....	46.6	30.12	71.6	64.4
.....	4.121	"	"	"	73.4	67.
3.307	.....	11 A. M.	48	30.05	73.4	65.5
.....	4.394	"	"	"	75.2	67.
2.838	.....	2 P. M.	50.5	30.01	72.5	65.5
.....	3.973	"	"	"	76.	68.
3.752	.....	5 P. M.	56	29.95	69.8	65.5
.....	4.170	"	"	"	72.5	68.

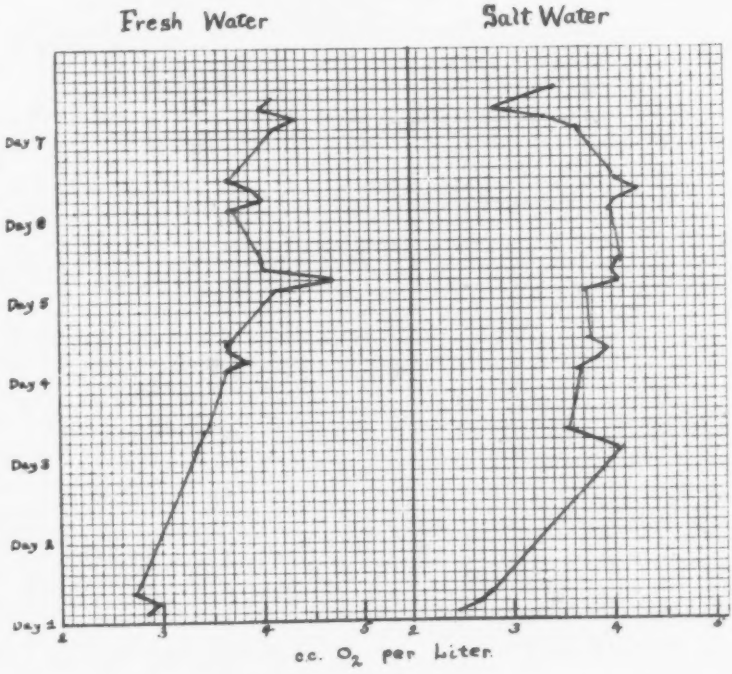
Salnity, 11,341.6 parts Chlorin per million.

(Here follow three diagrams marked Exhibit 216, pages 15, 16, 17.)

Diagram I.

Oxygen Curves, Fresh and Salt Water.

April 5-11, 1913.



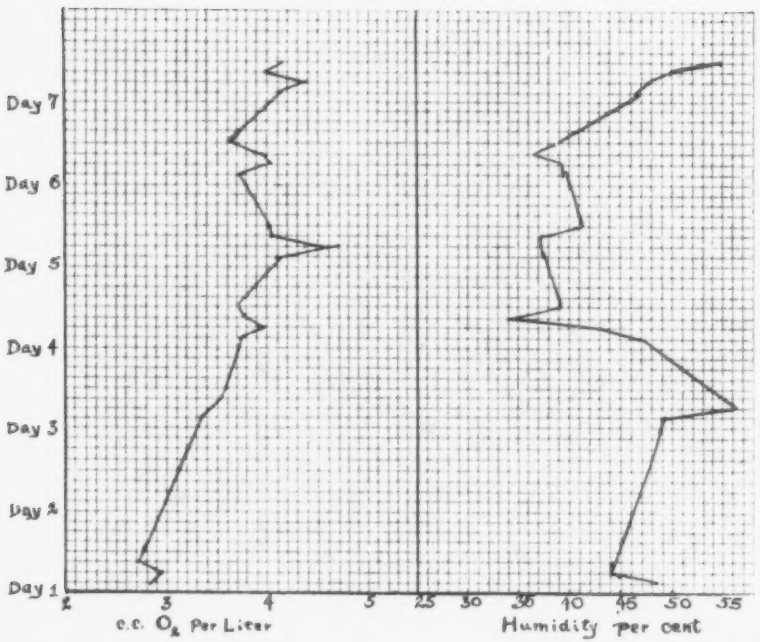
(Exhibit No 216-A. 15)

Diagram II

Humidity and Oxygen Curves.

Fresh Water

April 5-11, 1913, inclusive



(Exhibit No 216, p. 16)

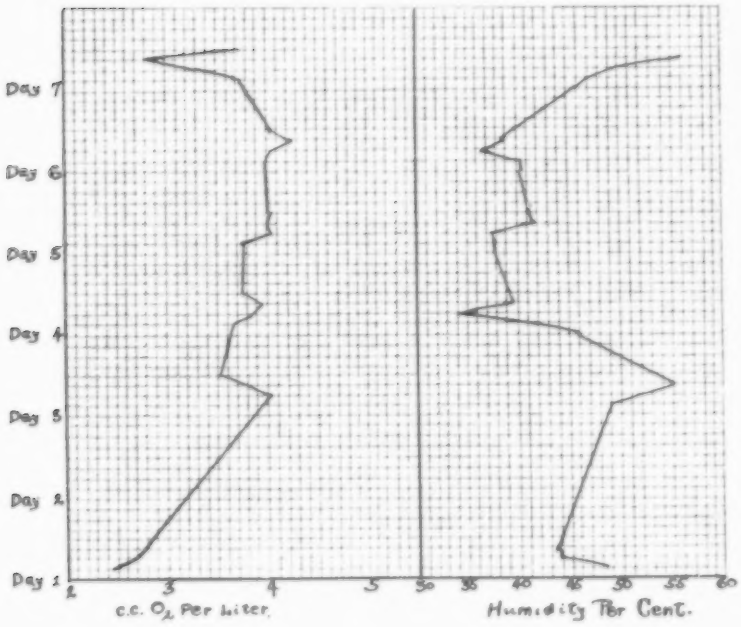
Diagram III

Humidity and Oxygen Curves.

Salt Water

11,341.6 parts chlorin per million

April 5-11, 1913, inclusive.



(Fr fisher Nr 216 & 17)

18 *Some of the Results.*

1. Increase of oxygen per liter from first reading of first day to last reading of last day,

Salt water..... 1.313 c. c.
Fresh water..... 1.303 c. c.

Average rate of increase per day,

Salt water..... 0.1877 c. c.
Fresh water..... 0.1861 c. c.

If sea water of this salinity, namely 11,341.6 parts Chlorine per million, i. e., approximately 61% sea water, contains at this temperature 5.9 c. c. oxygen per liter at saturation, and fresh water at this temperature contains 6.482 c. c. oxygen per liter at saturation, the above increase, in terms of per cent, is—

Salt Water, from 41% to 63%, total 22%.
Fresh Water, " 44% " 64%, " 20%.

2. Examination of Diagram I shows that, whatever may be the cause of the fluctuations, it affects both waters in the same way, for, in general, the curves break in the same direction. On these seven days, the changes of less than 1/10 of an inch in pressure and of about ½ degree Centigrade in temperature indicate practically constant conditions. But humidity changes are more perceptible, and reference to Diagrams II and III shows at four points, at least, that where humidity increased, on Day 1, Day 4, Day 5 and Day 6, oxygen content increased.

Some General Conclusions.

While salt water contains less oxygen at saturation than fresh water, both seem to absorb oxygen at the same rate, between
19 40% and 60% of saturation.

The absorption of oxygen by both fresh and salt water, is not so rapid as has been supposed, being in this instance about 0.18 c. c. per day, or about 3% of saturation value per day.

The effect of humidity is suggested by the results of the determinations; the greater the humidity, the less the absorption. Further investigation along this line will be carried out in this laboratory.

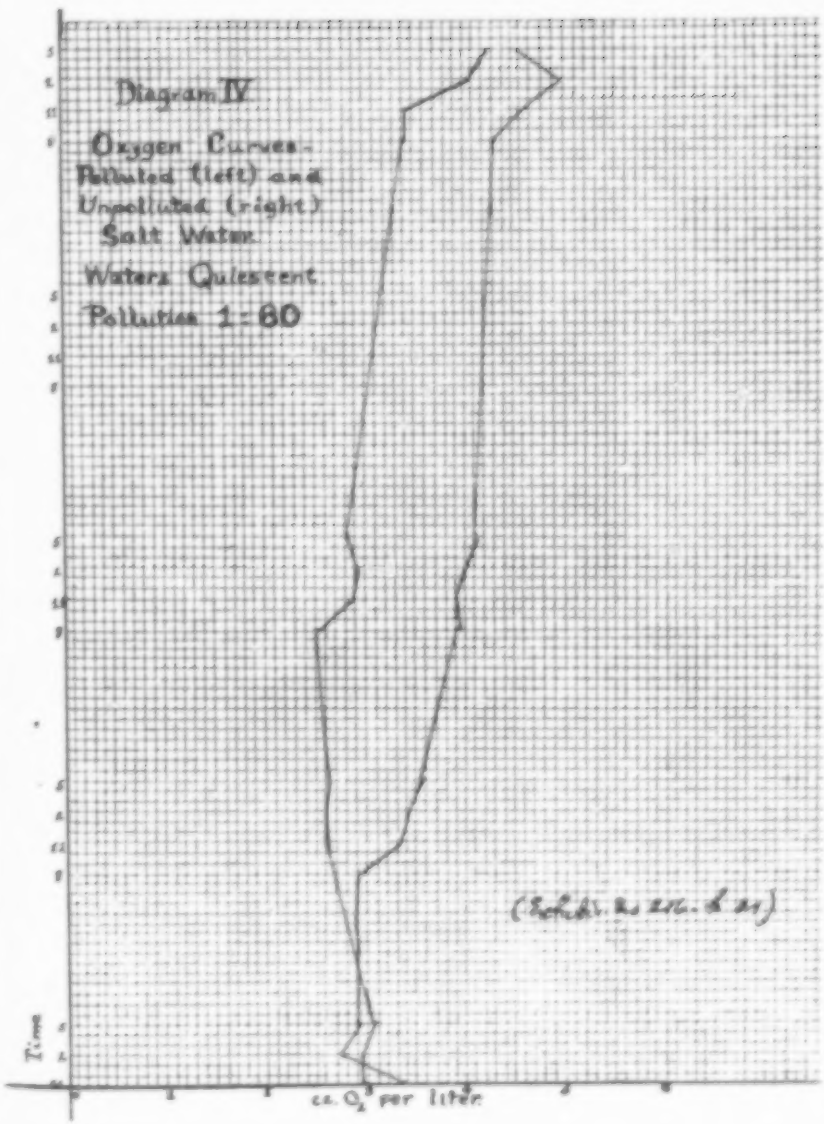
20 TABLE II.

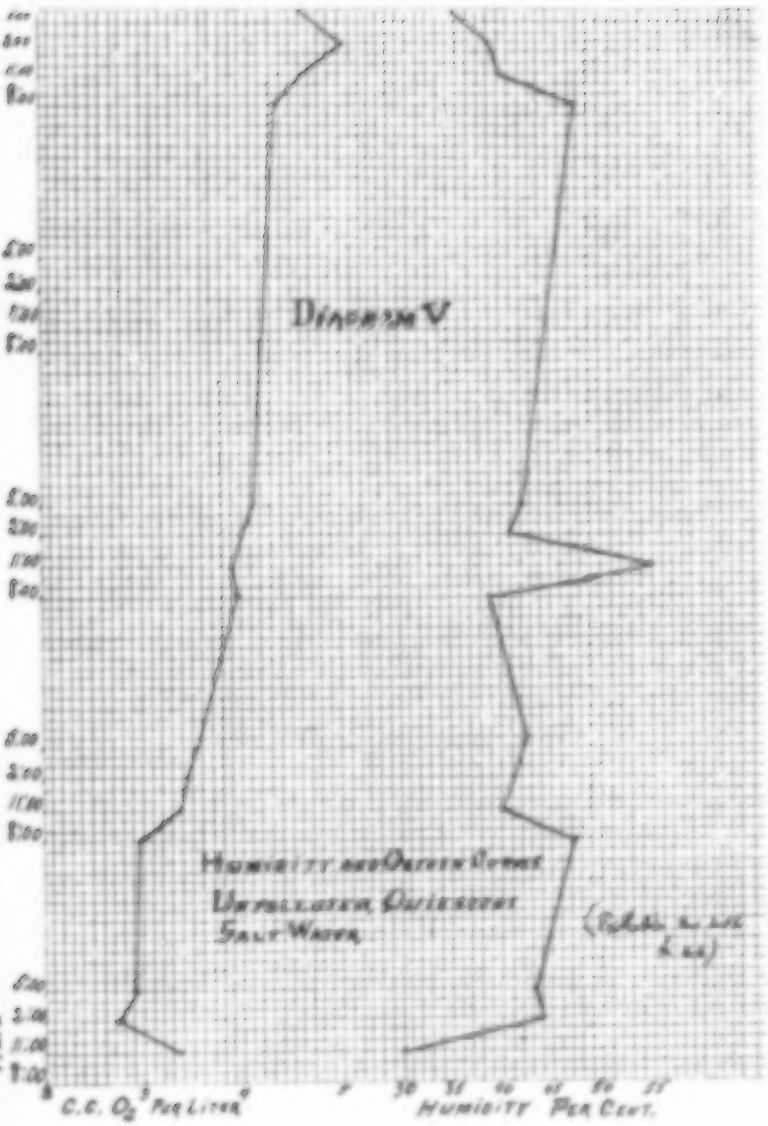
Oxygen Absorption by Polluted and Unpolluted Salt Water Under the Same Conditions.

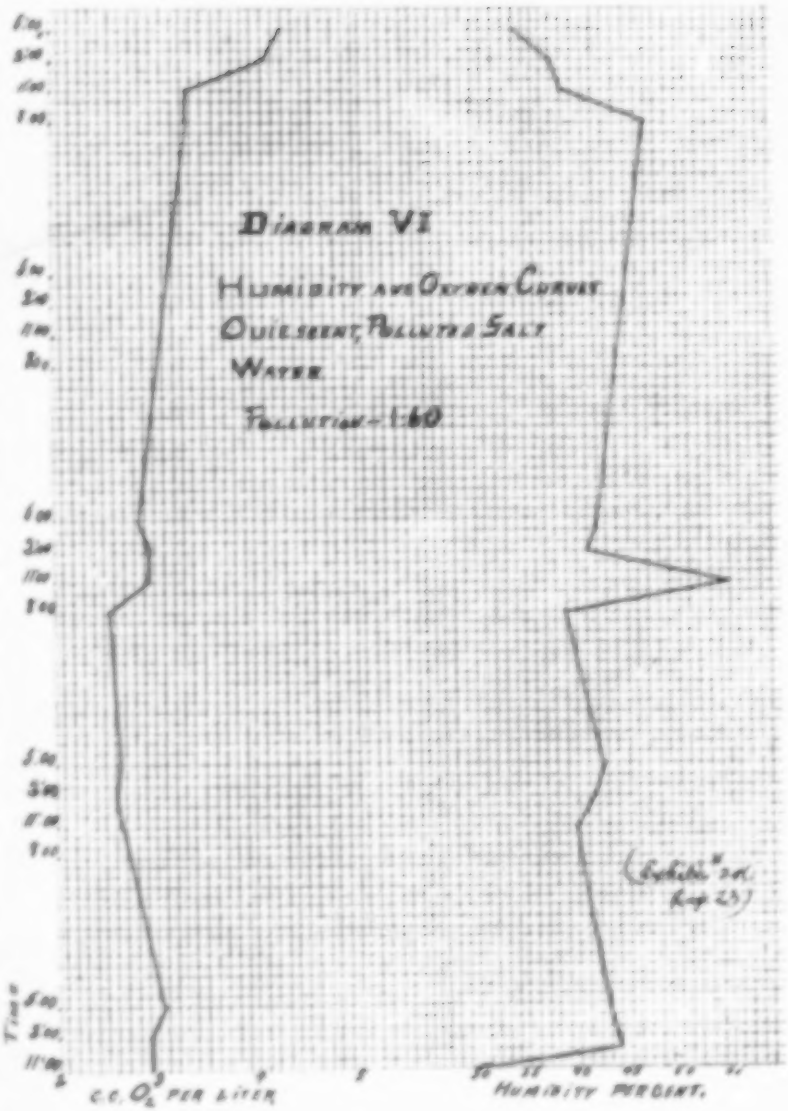
Polluted.	Unpolluted.	Time.	Humidity, %.	Barometer, in.	Temp. air.	Temp. water.
c. c. oxygen per liter.						
2.924	.....	11 A. M.	30.0	29.81	64.4	80.6
.....	3.384	"	"	"	69.8	78.8
2.924	.....	2 P. M.	44	"	66.2	78.8
.....	2.750	"	"	"	69.8	78.8
3.086	.....	5 P. M.	43.5	29.79	65.5	75.2
.....	2.934	"	"	"	71.6	78
.....	2.989	8 A. M.	47.5	29.88	74.5	74.5
2.644	.....	11 A. M.	40.0	29.79	71	71.6
.....	3.384	11 A. M.	40.0	"	72.5	73.4
2.621	.....	2 P. M.	41.5	29.72	71.6	71
.....	3.437	"	"	"	72.5	72.5
2.643	.....	5 P. M.	42.5	29.68	71.6	71
.....	3.567	"	"	"	73.4	73.4
2.545	.....	8 A. M.	40.0	29.55	73.4	69.8
.....	3.055	"	"	"	75.2	71.6
2.908	.....	11 A. M.	35	29.61	66.2	69.8
.....	3.921	"	"	"	71	71.6
2.924	.....	2 P. M.	41	29.79	67	69
.....	4.055	"	"	"	69	71
2.840	.....	5 P. M.	42	29.76	67	69
.....	4.115	"	"	"	68	69.8
		One day (Sunday) intervening.				
3.485	.....	8 A. M.	48	30.23	67	64
.....	4.377	"	"	"	69	64.4
3.465	.....	11 A. M.	30	30.20	64.4	64
.....	4.663	"	"	"	68	64.4
4.143	.....	2 P. M.	38	30.18	73.4	64.4
.....	5.034	"	"	"	74.5	65.5
4.304	.....	5 P. M.	34.5	30.15	63.5	64.4
.....	4.612	"	"	"	66.2	64.4

Salinity, polluted water, 13,209.8.
Salinity, unpolluted water, 12,684.8.
Pollution, 1 gallon of sewage to 60 gallons of water.

(Here follow three diagrams marked Exhibit No. 216, pages 21, 22, and 23.)


Diagram IV
Oxygen Curves.
Polluted (left) and
Unpolluted (right)
Salt Water
Waters Quiescent
Pollution 1:60
Time
cc. O2 per liter


Time
C.C. O_2 per Litre
Humidity per Cent.


DIAGRAM VI
HUMIDITY AND OXYGEN CURVES
QUIESCENT, POLLUTED SALT
WATER
POLLUTION - 1:60
(Exhibit 11 Dr. Rep. 23)
TIME
C.C. O_2 PER LITER
HUMIDITY PERCENT.

24 SERIES II.

Comparison of Polluted and Unpolluted Quiescent Salt Waters.

A.

For this series, the upper tank was filled with salt water, salinity 12,684.83 parts Chlorine per million, or approximately 68% sea water, and the lower tank with salt water, salinity 13,309.8 parts chlorine per million, or approximately 72% sea water. To the water in the lower tank, after cooling from heating, 55 gallons of sewage was added, giving approximately a proportion of sewage to water of one to sixty (1:60). Determinations of dissolved oxygen were begun immediately following the addition of the sewage, and samples were taken at three hour periods for five days. Readings are given in Table II and curves in Diagrams IV and V.

Some of the Results.

1. Increase of oxygen per liter from first reading of first day to last reading of last day,

Unpolluted Salt Water	1.226 c. c.
Polluted Salt Water	1.380 c. c.

Average rate of increase per day,

Unpolluted Salt Water	0.245 c. c.
Polluted Salt Water	0.276 c. c.

If the salt water of the salinity of the polluted water contains 5.68 c. c. oxygen per liter, at the temperature of this series, and salt water of the salinity of the unpolluted water contains 5.7 c. c. oxygen per liter at this temperature, the above increases in terms of per cent are—

25 Unpolluted Salt Water, 59% to 80%, total 21%.
Polluted Salt Water, 51% " 75%, " 24%.

2. The curve given in Diagram IV shows that the first two days the curves diverge, the polluted water showing decreasing oxygen. Beginning at eight o'clock on the third day, and continuing two days, there is a steady increase of oxygen in both waters.

3. Comparison of the humidity and oxygen curves shows what Diagrams II and III show, namely, when humidity increases, oxygen decreases. The variations in any two successive readings of barometer and water temperature are very slight. This seems to indicate the effect of humidity.

4. The greater rate of absorption in this series as compared with

Series I is difficult to account for. The average humidity in both series is about the same, 43.6 in the first and 42.4 in the second. The barometric readings are approximately the same in the two series, and there is not a great deal of difference in the water temperatures on the Centigrade scale. The salinity varies a little, but the difference does not seem great enough to account for the greater rate of absorption.

Some General Conclusions.

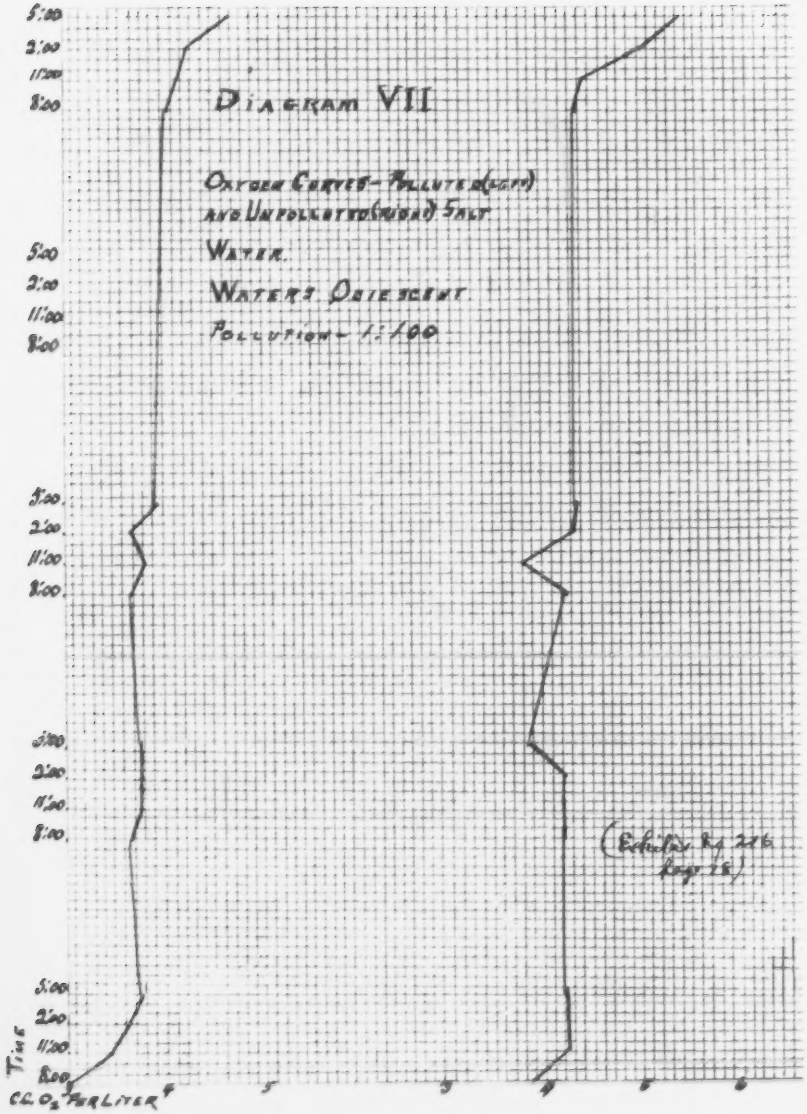
The absorption of oxygen by salt water may under certain conditions reach the average rate of 0.276 c. c. per liter per day.

When quiescent salt water is polluted with sewage at a dilution of one to sixty, the first effect is a decrease of the oxygen
26 content, but after two days, the rate of absorption is quite as rapid as that of unpolluted salt water. It would seem then, that a dilution in this proportion is not permissible in quiescent salt water.

27 **TABLE III.**

Oxygen Absorption by Polluted and Unpolluted Salt Water Under the Same Conditions.

Polluted. c. c. oxygen per L.	Unpolluted.	Time.	Humidity, %.	Barometer, in.	Temp. air.	Temp. water.
3.040	.....	8 A. M.	81	30.08	66.2	68
.....	3.891	"	"	"	68	66.2
3.485	.....	11 A. M.	66.5	30.07	71	67
.....	4.234	"	"	"	71	66.2
3.625	.....	2 P. M.	53	30.03	73.4	66.2
.....	4.234	"	"	"	73.4	67
3.789	.....	5 P. M.	"	30.01	73.4	67
.....	4.234	"	"	"	71.6	68
3.683	.....	8 A. M.	49	30.02	71.6	68
.....	4.211	"	49	"	71.6	68
3.789	.....	11 A. M.	60	30.01	71.6	68
.....	4.119	"	"	"	71.6	68
3.789	.....	2 P. M.	61	29.96	72.5	68
.....	4.234	"	"	"	72.5	69
3.789	.....	5 P. M.	62	29.97	72.5	68
.....	3.891	"	"	"	71.6	69
3.683	.....	8 A. M.	77	29.95	69	68
.....	4.257	"	"	"	69.8	69
3.800	.....	11 A. M.	63	29.92	71	69
.....	3.799	"	63	"	71	69
3.683	.....	2 P. M.	54	29.89	73.4	68
.....	4.325	"	"	"	73	69
3.952	.....	5 P. M.	49	29.88	71.6	66.2
.....	4.371	"	"	"	71.6	68


Diagram VII
Oxygen Curves - Polluted (light) and Unpolluted (shaded) Salt Water.
Water's Odiferent
Pollution - 1:100
5:00
2:00
11:00
8:00
Time
cc O2 per liter
(Bulletin No. 226 Page 15)

One day (Sunday) intervening.

Polluted. c. c. oxygen per L.	Unpolluted.	Time.	Humidity, %.	Barometer, in.	Temp. air.	Temp. water.
4.092	.....	8 A. M.	83	29.61	64	66.2
.....	4.394	"	"	"	66.2	68
4.139	.....	11 A. M.	75	29.58	65.5	66.2
.....	4.554	"	"	"	66.2	66.2
4.256	.....	2 P. M.	82	29.57	63.5	66.2
.....	5.057	"	"	"	66.2	68
4.677	.....	5 P. M.	76	29.56	63.5	66.2
.....	5.424	"	"	"	66.2	67

Salinity, polluted water, 13,610.7 parts chlorin per million.
Salinity, unpolluted water, 11,897.8 " " " "
Pollution, 1 gallon sewage to 100 gallons water.

(Here follows diagram marked Exhibit No. 216, page 28.)

29

Series II.

Comparison of Polluted and Unpolluted Quiescent Salt Waters.

B.

For this series, the upper tanks was filled with salt water, of the salinity of 13,610.7 parts Chlorine per million, approximately 73% sea water, and the lower tank with salt water of the salinity 11,897.8 parts Chlorine per million, or approximately 64% sea water. To the water in the lower tank, after cooling from heating, approximately 30 gallons of sewage was added, giving a dilution of one to one hundred. Dissolved oxygen content was determined immediately after the addition of the sewage, and at three hour periods thereafter for five days. The readings are given in Table III and the curves in Diagram VII.

Some of the Results.

1. Increase of oxygen content per liter from first reading of first day to last reading of last day,

Unpolluted Salt Water	1.533 c. c.
Polluted Salt Water	1.637 c. c.

Average rate of increase per day,

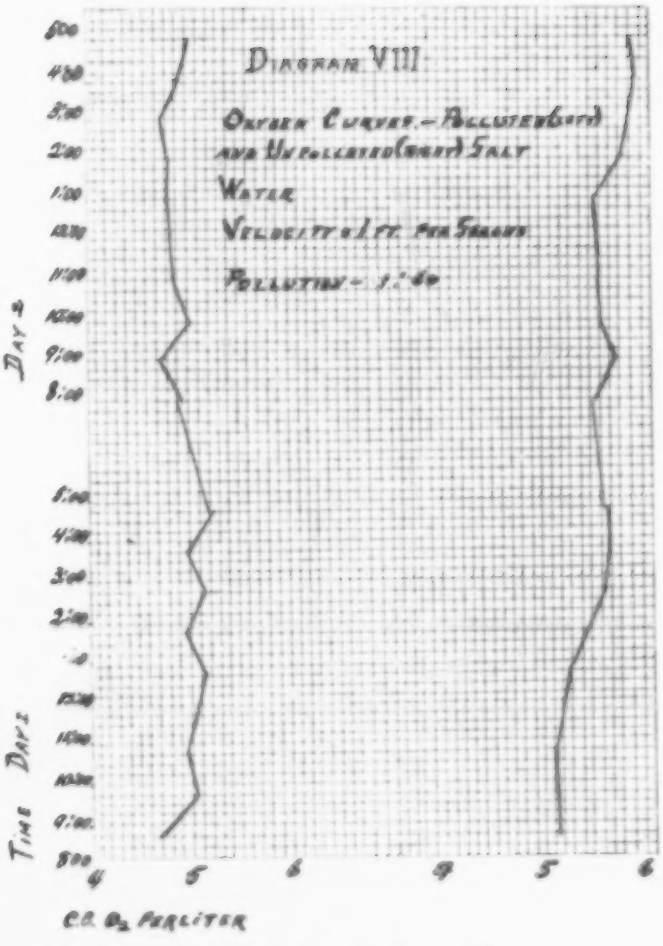
Unpolluted Salt Water	0.306 c. c.
Polluted Salt Water	0.327 c. c.

2. The curves given in Diagram VII show a very slight divergence after the first day and to the beginning of the third day. It would seem therefore, that a dilution of pollution of 1:100 was about what quiescent salt water of that salinity will stand.

30 3. If fluctuations are due to humidity, it is not so apparent in this series as in the first two. At one point in each of the five days, an increase in oxygen content was accompanied by a decrease in humidity; but at other points the oxygen content remained constant, or the change was in the same direction as the change in humidity.

Some General Conclusions.

The absorption of oxygen by quiescent salt water may, under certain conditions, reach the average of 0.306 c. c. per day. Quiescent salt water seems to be able to take care of pollution of one gallon of sewage to 100 gallons of salt water.



(Exhibit No 226, Page 32)

TABLE IV.

Oxygen Absorption by Polluted and Unpolluted Water in Motion Under the Same Conditions.

Polluted. c. c. oxygen per L.	Unpolluted.	Time.	Humidity, %.	Barometer, in.	Temp. air.	Temp. water.
4.699	.....	8 A. M.	48.5	29.90	58	55.4
.....	5.143	"	"	"	60.8	55
5.0478	.....	9 A. M.	40	29.91	60	55.4
.....	5.149	"	"	"	60.8	55
4.980	.....	10 A. M.	47	"	59	55.4
.....	5.149	"	47	"	60.8	55
5.165	.....	12 M.	43.5	29.85	62	55.4
.....	5.264	"	"	"	62.6	55
4.989	.....	1 P. M.	37	29.83	64.4	56.5
.....	5.434	1 P. M.	"	"	64.4	54.5
5.048	.....	2 P. M.	43	29.82	64.4	55.
.....	5.618	"	"	"	64.4	55
4.938	.....	3 P. M.	34.5	29.82	64.4	55
.....	5.664	"	"	"	64.4	55
5.228	.....	4 P. M.	36	"	64.4	53.6
.....	5.664	"	"	"	64.4	53.6
4.932	.....	8 A. M.	59.5	29.74	59	55.4
.....	5.584	"	"	"	56.5	56.5
4.711	.....	9 A. M.	65	29.72	60	55.4
.....	5.744	"	"	"	57.2	56.5
5.048	.....	10 A. M.	57	29.68	60.8	55.4
.....	5.607	"	"	"	60.8	57.2
4.874	.....	11 A. M.	55	"	60.8	55.4
.....	5.607	"	"	"	60.8	57.2
4.816	.....	1 P. M.	62	29.64	62.6	55.4
.....	5.584	"	"	"	63.5	57.2
4.816	.....	2 P. M.	51	"	64.4	55.4
.....	5.813	"	"	"	64.4	57.2
4.758	.....	3 P. M.	58	29.68	64.4	55.4
.....	5.905	"	"	"	64.4	57.2
4.932	.....	4 P. M.	61	29.71	62.6	55.4
.....	5.950	"	"	"	62.6	57.2
5.106	.....	5 P. M.	62	"	62.6	55.4
.....	5.927	"	"	"	62.6	57.2

Salinity, polluted water, 13,240 parts chlorin per million.
Salinity, unpolluted water, 12,730 " " " "
Pollution, 1 gallon sewage to 60 gallons water.
Velocity, 1 foot per second.

(Here follows diagram marked Exhibit No. 216, page 32.)

33 SERIES III.

Comparison of Polluted and Unpolluted Salt Water in Motion.

A.

For this series the upper tank was filled with salt water, of the salinity 12,730 parts Chlorine per million, or approximately 68% sea water, and the lower tank was filled with salt water of the salinity of 13,340 parts Chlorine per million, or approximately 72% sea water. To the water in the lower tank approximately 55 gallons of sewage was added, giving a solution of approximately 1:60, the same dilution as in Series IIA, where the waters were quiescent. Oxygen and other determinations were begun immediately after the sewage was added, the water set in motion at a velocity of 1 foot per second, and determinations were made every hour. The readings are recorded in Table IV and the curves in Diagram VIII.

Some of the Results.

1. Increase in oxygen content per liter from beginning of first day to end of first day,

Unpolluted Salt Water	0.515 c. c.
Polluted Salt Water	0.523 c. c.

Increase in oxygen content per liter from beginning of second day to end of second day,

Unpolluted Salt Water	0.343 c. c.
Polluted Salt Water	0.174 c. c.

2. The curves show the general tendency to increase of oxygen content in both polluted and unpolluted waters, while the rate of both in the second day is less than the first, and that of the
34 polluted water much less, from the starting point of each day there is an increase toward the end of the day. During the night between the two days, when the waters were quiescent, the reduction in oxygen content of the polluted water was more marked than in the unpolluted water, but soon after the water began to move there was an increase in the oxygen content.

3. During the first day the humidity ranged from 48.5 in the morning to 36.0 in the afternoon, while during the second day it ranged from 59.5 in the morning to 62 in the evening, thus being greater on the second day, when the rate of absorption was less.

Some General Conclusions.

Unpolluted salt water moving at the rate of one foot per second, compared with quiescent, unpolluted salt water, shows rates of increase in oxygen content per day as follows:

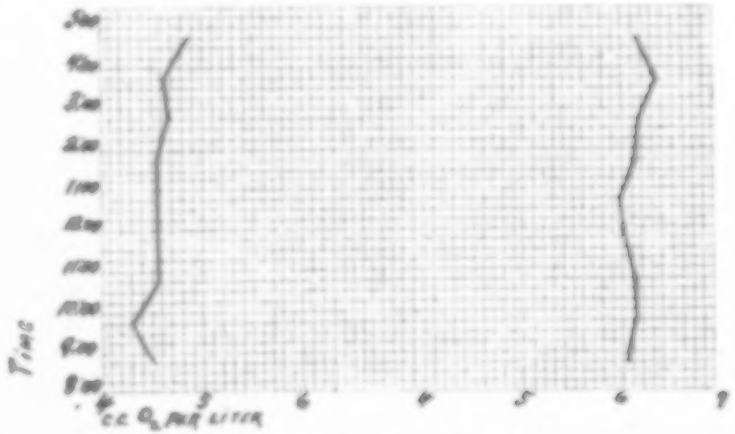
Diagram IX

Oxygen Curves - Polluted (left) and Unpolluted (right) Salt Water

Velocity 1 ft. per second

Pollution 1:30

(Unpolluted continuation of Diagram VIII)



(Rubner, p. 226)

Quiescent unpolluted salt water				0.245	Series IIA
"	"	"	"	0.306	" IIB
Moving	"	"	"	0.389	" IIIA

Polluted salt water, moving at the rate of one foot per second, compared with quiescent salt water of the same degree of pollution, namely 1:60, shows rates of increase per day as follows:

	First day.	Second day.
Quiescent, Polluted Salt Water	0.162 c. c.	no change
Moving Polluted Salt Water	0.523	0.174

It would therefore seem that a salt water moving at the rate of one foot per second could take care of more sewage than quiescent salt water.

15 TABLE V.

Oxygen Absorption by Polluted and Unpolluted Water in Motion Under the Same Conditions.

Polluted. c.c. oxygen per L.	Unpolluted.	Time.	Humidity, %.	Barometer, in.	Temp. air.	Temp. water.
4.326	.....	8 A. M.	69	29.86	69.8	55.4
.....	6.065	"	"	"	57.2	58
4.256	.....	9 A. M.	61.5	"	69.8	55.4
.....	6.122	"	"	"	69.8	57.2
4.272	.....	10 A. M.	50	29.86	69.8	55.4
.....	6.122	"	"	"	69.8	57.2
4.584	.....	12 M.	53	29.80	62.6	55.4
.....	5.980	"	"	"	63.5	58
4.584	.....	1 P. M.	42.5	"	65.5	55.4
.....	6.122	"	43.5	"	64.4	58
4.080	.....	2 P. M.	41.5	"	65.5	55.4
.....	6.179	"	"	"	65.5	58
4.642	.....	3 P. M.	47	"	62.6	55.4
.....	6.351	"	"	"	63.5	58
4.674	.....	4 P. M.	37	"	58	55.4
.....	6.179	"	"	"	63.5	57.2

Salinity, polluted water, 13,000 parts chlorin per million.
Unpolluted water continuation of water used in Table IV.
Pollution, 1 gallon sewage to 30 gallons water.
Velocity, 1 foot per second.

(Here follows diagram marked Exhibit No. 216, page 36.)

37 SERIES III.

Comparison of Polluted and Unpolluted Salt Waters in Motion.

B.

For this series the upper tank was not changed, and the lower tank was filled with salt water of the salinity of 13,030 parts Chlorine per million and approximately 100 gallons of sewage were added. Oxygen and other readings were begun immediately and the water set in motion at the rate of one foot per second. The readings are given in Table V and the curves in Diagram IX.

Some of the Results.

Increase in oxygen content in one day, in the polluted water, is 0.348 c. c. Compared with the first day of other polluted salt waters, we get the following:

	Increase 1st day.
Quiescent, polluted salt waters (1:60)	0.162 c. c.
Moving " " " (1:60)	0.523 c. c.
" " " " (1:30)	0.348 c. c.

It would appear that moving salt water can take care of a large quantity of sewage, if the sewage can be evenly distributed through it.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

Here Follow

DEFENDANTS' EXHIBITS

Nos. 4, 6, 7.

JAMES D. MAHER,
Commissioner.

United States of America.

WAR DEPARTMENT.

Washington, February 21, 1913

I hereby certify that the attached papers are true copies of papers of record on file in the Office of the Chief of Engineers, U. S. Army.

W. H. Bixby

Chief of Engineers, U. S. Army.

[One copy each of 20103/297, permit dated September 22, 1911, and 20103/97, permit dated May 11, 1910, and stipulation or contract dated April 14, 1910 attached] [Copies of the two drawings attached to the permit dated May 11, 1910, not furnished]

I hereby certify that W. H. Bixby, who signed the foregoing certificate, is the The Chief of Engineers, U. S. Army, and that to his certification as such full faith and credit are and ought to be given.

In testimony whereof I, Henry L. Stimson, Secretary of War, have hereunto caused the Seal of the War Department to be affixed and my name to be subscribed by the Assistant and Chief Clerk of the said Department, at the City of Washington, this 21st day of February 1913.

Henry L. Stimson
Secretary of War.

By John C. Scofield
Assistant and Chief Clerk.

WAR DEPARTMENT
Standard Form No. 14.

5-1000

J. A. G. C.
(21290)

WHEREAS, In compliance with the requirements of a permit, dated May 11, 1910, THE PASSAIC VALLEY SEWERAGE COMMISSION (grantee therein) has now submitted to the Secretary of War, for his examination and approval, detailed plans of a sewer outlet and shaft house proposed to be constructed by said Commission in New York Bay; which plans have been recommended by the Chief of Engineers, United States Army, and as to which the DEPARTMENT OF COMMERCE AND LABOR will interpose no objections, provided the approval of said plans is given subject to the conditions hereinafter embodied:

NOW, THEREFORE, This is to certify that the Secretary of War hereby approves the plans for the said sewer outlet and shaft house, at said place, submitted as aforesaid; which said plans are shown on 60 blueprints marked "Ace No. B1000 - 1060", inclusive; and also bear the file number of the Office of the Chief of Engineers, United States Army "20103,111-170", and are referred to as a part of this permit.

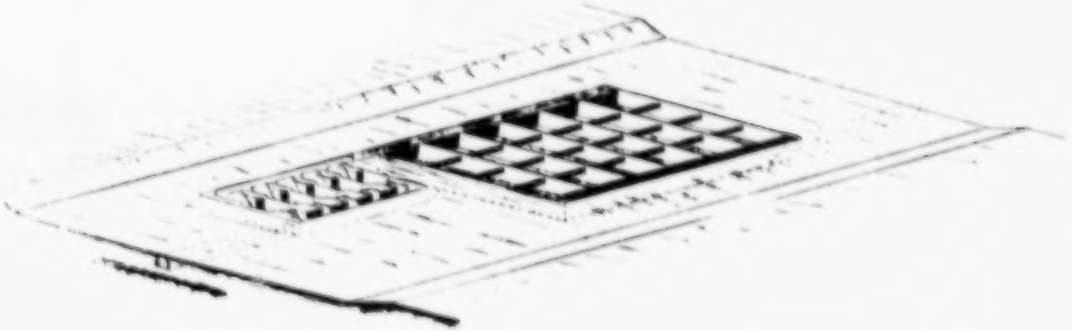
This approval is given subject to the following conditions and provisions.

1.---That the conditions of the general permit of May 11, 1910, shall apply to the work herein approved.
2.---That for such details as are not yet determined upon, or are not sufficiently shown on said plans, further detailed plans shall be submitted for consideration when required by the district engineer officer.
3.---That no part of the terminal structure shall be less than 350 feet distant from the center of the Robbins Reef Light Station.
4.--That the terminal structure shall not be more than 40 feet high above mean low water.
5.---That the United States shall be reimbursed by the Passaic Valley Sewerage Commission for any expense to which it may be put on account of inspection of the works herein authorized.

WITNESS my hand this 22 day of SEPTEMBER, 1911.

Robert Shaw Oliver

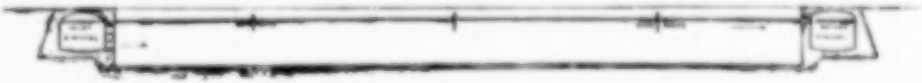
Acting Secretary of War.



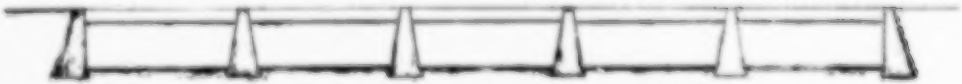
PASSAIC VALLEY SEWERAGE COMMISSIONERS

SCREENING APPARATUS AND SETTLING TANKS

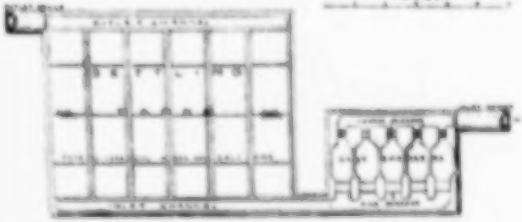
NEWARK BAY PUMPING STATION



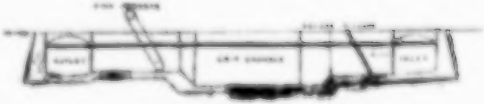
LONGITUDINAL SECTION THROUGH TANKS



TRANSVERSE SECTION THROUGH TANKS



GENERAL PLAN



SECTION THROUGH GRIT AND SEWER CHAMBERS

SCREENING APPARATUS AND SETTLING TANKS

Whereas, By Section 10 of an act of Congress, approved March 3, 1899, entitled "An act making appropriations for the construction, repair, and preservation of certain public works on rivers and harbors, and for other purposes," it is provided that it shall not be lawful to build or commence the building of any wharf, pier, dolphin, boom, weir, breakwater, bulkhead, jetty, or other structure in any port, roadstead, haven, harbor, canal, navigable river, or other water of the United States, outside established harbor lines, or where no harbor lines have been established, except on plans recommended by the Chief of Engineers and authorized by the Secretary of War; and it shall not be lawful to excavate or fill, or in any manner to alter or modify the course, location, condition, or capacity of, any port, roadstead, haven, harbor, canal, lake, harbor of refuge, or inclosure within the limits of any breakwater, or of the channel of any navigable water of the United States, unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War prior to beginning the same:

AND WHEREAS, THE PASSAIC VALLEY SEWERAGE COMMISSION has applied to the Secretary of War for permission to locate a sewer outlet with shaft house in NEW YORK BAY, in the vicinity of Robbins Reef Light, and to construct the necessary appurtenant works, in accordance with the attached agreement and plans, which have been approved by the Chief of Engineers, United States Army;

NOW, THEREFORE, This is to certify that the Secretary of War hereby gives permission unto the said THE PASSAIC VALLEY SEWERAGE COMMISSION to locate a sewer outlet with shaft house in NEW YORK BAY, in the vicinity of Robbins Reef Light, and to construct the necessary appurtenant works, in accordance with said agreement and plans; subject to the following conditions:

1.---That the work herein permitted to be done shall be subject to the supervision and approval of the Engineer Officer of the United States Army in charge of the locality.

2.---That if at any time in the future it shall be made to appear to the Secretary of War that the work herein authorized is an unreasonable obstruction to the free navigation of said waters, said licensee will be required, upon due notice from the Secretary of War, to remove or alter the same so as to render navigation through said waters reasonably free, easy, and unobstructed.

3.---That the tunnel under Newark Bay shall be constructed so as to give a clear depth of not less than thirty-five (35) feet at mean low water in the navigable channel.

4.---That the gate-house near Robbins Reef Light shall be erected at the point and under such plans as the Secretary of War, after consultation with the Secretary of the Department of Commerce and Labor, may hereafter approve; except as may be required in any particular by the terms of a stipulation or contract, of which a copy is hereto attached, made between the United States and the Passaic Valley Sewerage Commissioners under date April 14, 1910, whereby the parties to that stipulation or contract adjusted

the matters controverted between them in the suit of the People of the State of New York (United States, Intervenor) V. The State of New Jersey and Passaic Valley Sewerage Commissioners, being Number 6 on the Original Docket of the Supreme Court of the United States for the October Term, 1909.

5.---That the Passaic Valley Sewerage Commission shall remove from the waters of New York Harbor any shoals when the Secretary of War shall be satisfied that the same result from the discharge from the proposed tunnel and shall direct their removal.

6.---That all the terms and requirements of the divisions numbered First and Second of said stipulation or contract between the United States and the Passaic Valley Sewerage Commissioners, mentioned above, be at all times met and satisfied, according to the true intent of said contract.

IT IS UNDERSTOOD that this instrument simply gives permission under said Act of Congress to do the work herein authorized; that it does not give any property rights, and does not authorize any injury to private property or invasion of private rights.

WITNESS my hand and this 11 day of May, 1910.

Jno Dickinson

Secretary of War.

IN THE SUPREME COURT OF THE UNITED STATES.

October Term, 1 9 0 9.

THE PEOPLE OF THE STATE OF NEW YORK,

Complainants,) In Equity.

V.) No. 6 Original on the Docket for said October Term.

THE STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS

Defendants.)

****

STIPULATION.

The United States having intervened in the above entitled suit with the consent of the court, and it being desired by the United States and the defendants in the suit to adjust the matters in controversy between them, in the manner and upon the terms and conditions hereinafter stated, and the State of New Jersey, by an act of its Legislature, approved on the eighth day of April, nineteen hundred and ten, having authorized the defendant, the Passaic Valley Sewerage Commissioners, to make this adjustment, IT IS NOW STIPULATED AND AGREED by and between the United States and the Passaic Valley Sewerage Commissioners, defendants in the suit, as follows:

First: The Passaic Valley Sewerage Commissioners agree with the United States that the sewer system to which the suit relates shall be constructed, maintained and operated if at all, in accordance with the following requirements:

(a) Upon the line of the trunk sewer and which it is proposed shall be constructed, and at a point at or near the

pumping station to be located on the Newark Meadows near the Newark Bay, it is stipulated and agreed that the sewage, waste and other matter passing through the said trunk sewer shall first pass through coarse screens to remove therefrom all large floating matter, and after passing through such coarse screens shall pass through a grit basin or basins where the heavy matter therein shall be taken out as far as practicable, from which basin or basins the sewage and other matter shall pass through self-cleansing mechanical screens having clear openings of not over 4/10 of an inch.

(b) As the sewage comes from the fine screens, it shall also pass through sedimentation basins. The sewage after passing through said grit basin and said self-cleansing mechanical screens shall enter the sedimentation basins or settling tanks consisting of a number of units, each approximately 225 feet long and 15 feet deep. Each tank will have a normal capacity of not less than 1,250,000 gallons, making an aggregate tank capacity sufficient to meet the requirements as stated herein. The tank capacity shall always be such as to provide a detention period of not less than one hour at the maximum rate of flow of the sewage and a detention period of the daily average flow of such sewage for not less than one hour and a half. The mean lineal velocities through said tanks shall not be over 0.5 inch per second for average flow, and 0.75 inch per second for the maximum flow. In addition to an in connection with these basins scum boards shall be provided to retain the floating matter, and proper and adequate devices shall be used to remove the retained scum and deposits from the settling basins; drawings of the general

plan of said settling tanks (sedimentation basins) as proposed at the outset being herewith attached as Appendix A.

(c) The sewage and waste thus screened and settled is then to flow into a pump well, whence it is to be pumped under pressure through a tunnel to a point in the New York Bay near Robbins Roof Light, at which point it is agreed that the matter passing through the said tunnel shall be dispersed into the waters of the New York Bay through a series of outlets discharging forty feet or more beneath the surface of the water at mean low tide. From the end of the tunnel connections shall be made with four or more discharge pipes extending across the current, spaced about one hundred feet apart, laid in trenches on the bottom of the Bay, and of a size decreasing in diameter from about six feet to two feet. On the top of these discharge pipes will be series of not less than one hundred and fifty tees of a diameter not exceeding one foot, and spaced approximately ten feet apart. On each of these vertical tees shall be placed outlets arranged to discharge horizontally across the tidal current, and the extent of the dispersion area used for this system of outlet pipes shall cover at least 3.5 acres of the bottom of the Bay.

Second. The Passaic Valley Sewerage Commissioners further agree with the United States that in the operation of said sewer system at all times the following results shall be secured, either through compliance with the requirements of the immediately preceding paragraphs, or through requisite lawful additional arrangements, viz:

(1) There will be absence in the New York Bay of visible suspended particles coming from the Passaic Vally Sewage.

(2) There will absence of deposits objectionable to the Secretary of War of the United States in the New York Bay coming from the Passaic Valley sewage.

(3) There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

(4) There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area of elsewhere.

(5) There will be no injurty to the public health which will be occasioned by the discharge from the said sewer in to the Bay of New York in the manner proposed and no public or private nuisance will be created thereby.

(6) The absence of injurious effect from said sewage discharge, upon the property of the United States situated in the Harbor of New York.

(7) The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life.

Third: The said Passaic Valley sewerage Commissioners further agree with the United States that so long as said sewer system, or any part thereof, is operated, the United States shall have, through such representatives as may be designated by the Secretary of War at any time for such purpose, full opportunity to inspect the condition and working of the sewer system, with a view to determining whether this contract is being in all respects performed, and that the said Passaic Valley Sewerage Commissioners will render such

expert or other assistance as the United States may desire in the course and in aid of such inspection and determination.

Fourth: The United States agrees with the Passaic Valley Sewerage Commissioners that forthwith upon the filing of this agreement, properly executed, in the office of the Clerk of the Supreme Court as a stipulation of the parties in the suit, it will discontinue its intervention in the above entitled suit and will cause its petition of intervention to be dismissed without prejudice, and will not again intervene in said suit.

Fifth: The United States and the Passaic Valley Sewerage Commissioners mutually agree, that this contract shall not become effective in any part, except the next succeeding divisions, unless or until all such permits as would be requisite under the statutes of the United States for the construction, maintenance or operation of said sewer system without this contract are actually obtained from the United States, or unless or until such permits are made conditional upon compliance at all times with all the terms and requirements of the divisions of this contract numbered First and Second, whether or not such permits contain other terms or conditions.

Sixth: The Passaic Valley Sewerage Commissioners hereby consent that full compliance at all times with the terms and requirements of the First and Second divisions of this contract be made express conditions of any permits issued by or on the part of the United States for construction, maintenance or operation of said sewer system, and agree with the United States that this contract shall establish such consent before all officers of the United States,

Seventh: It is agreed between the United States and the Passaic Valley Sewerage Commissioners that this contract shall bind and also shall enure to the benefit of the successors of the latter.

IN WITNESS WHEREOF this instrument has been executed in triplicate; being signed in the name and on behalf of the United States by the Attorney General of the United States and in the name and on behalf of the Passaic Valley Sewerage Commissioners by their president, and being sealed also on behalf of said Passaic Valley Sewerage Commissioners with their corportate seal attested by their secretary; all on the fourteenth day of April, Nineteen hundred and ten.

The United States of America
by Geo. W. Wickersham
Attorney General

Passaic Valley Sewerage Commissioners
by Julius A. Lebkuecher
Chairman & Pres't

Attest.
John S. Gibson,
Secretary and Clerk

No. 6, ORIGINAL.

IN THE SUPREME COURT OF THE UNITED STATES.

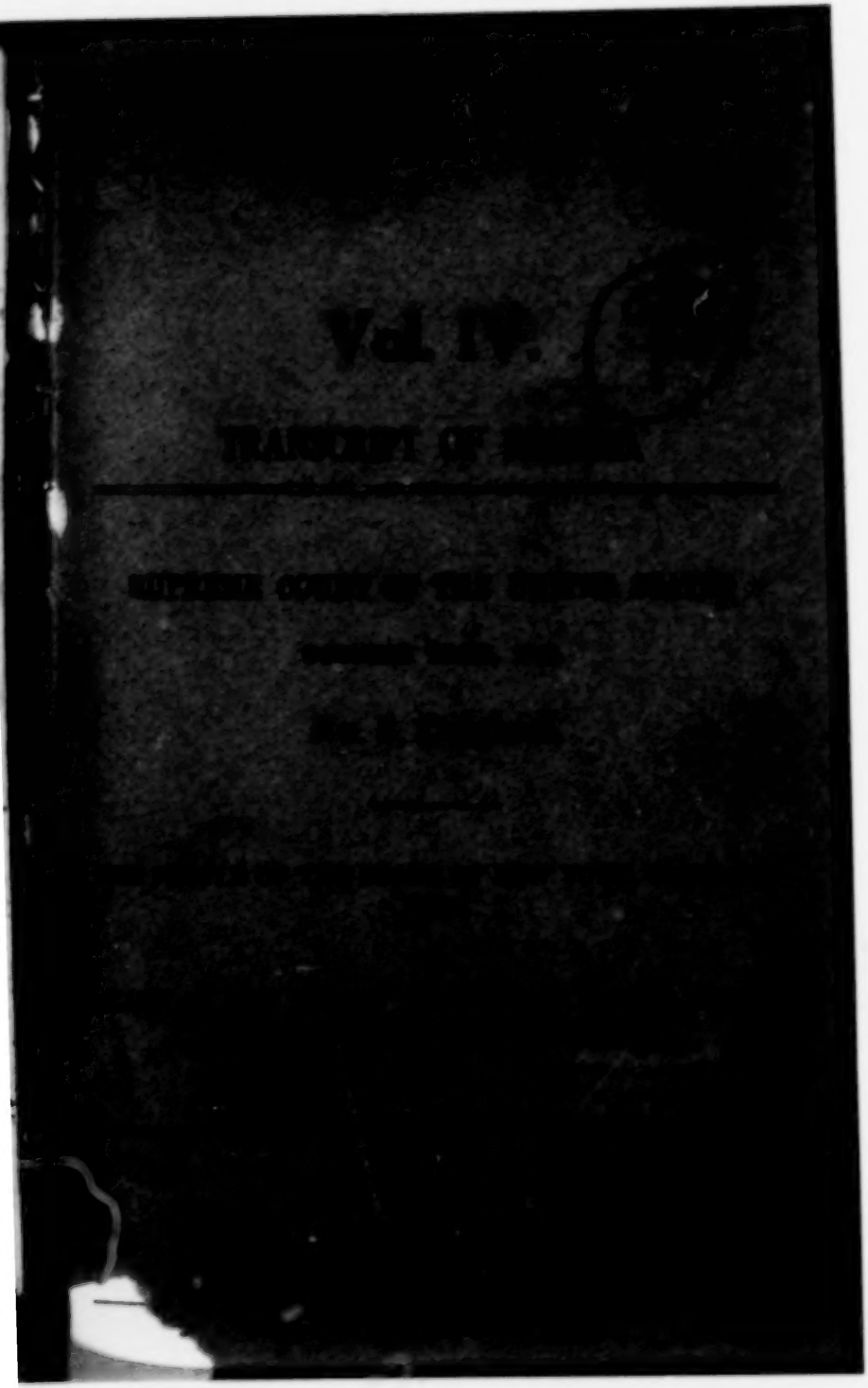
October Term, 1909.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,	)	
THE UNITED STATES, Intervener.	)	
-vs-	)	IN EQUITY.
THE STATES OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.	)	

In behalf of the State of New Jersey I approve of and consent to the making of the foregoing stipulation, and consent that the United States discontinue its intervention in the above entitled cause, and that the petition of the intervention of the United States be dismissed without prejudice.

Dated April 14, 1910.

Robert Hall Clarke
Special Counsel



SUPREME COURT OF THE UNITED STATES.

OCTOBER TERM, 1916.

No. 3, Original.

THE PEOPLE OF THE STATE OF NEW YORK, COMPLAINANTS,

vs.

STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS, DEFENDANTS.

VOLUME IV.

INDEX.

		Page.
Complainants' Exhibit	1—Stenographer's report of a public hearing given by the New York Harbor Line Board, December 9, 1908	2901
	2—Report of New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, March 31, 1905	3057
	Outline map of New York Harbor and vicinity	3057½
	3—Report of New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, April 30, 1906	3139
	Map	3139½
	4—Map	3175
	5—Map	3176
	6—Map	3177

JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C.

		Page.
Complainants' Exhibit	7—Map	3178
	8—Map	3179
	9—Map	3180
	10—Map	3181
	11—Map	3182
	14—Data relating to mud samples, Nos. 1 to 76, from New York Bay and vicinity, &c.	3183
	15—Diagram of boring device for sampling mud deposits, &c.	3206
	16—Coast chart No. 120	3207
	17—Charts showing location and samples taken at each station during 1907	3208
	18—Diagram of New York Bay and vicinity.	3217
	Lower Bay, westerly section	3218
	Lower Bay, central section	3219
	Lower Bay, easterly section	3220
	Narrows section	3220a
	Kill van Kull section	3221
	Battery section	3222
	Gowanus section	3222a
	Brooklyn Bridge to Blackwells Island	3223
	East River section	3224
	Wards Island section	3225
	Harlem River, easterly section	3226
	Harlem River, westerly section	3227
	Hudson River section, Battery to 59th street	3228
	Hudson River section, 59th to 129th streets	3229
	Hudson River section, 129th street to Spuyten Duyvil	3230
	Hudson River section, New York to Tarrytown	3230a
	20—Data relating to water samples, Nos. 1 to 951, from New York Bay and vicinity, &c.	3232
	21—Charts showing location and samples taken at each station during 1907	3274
	29—Opinion of Commission to Clarkin, July 25, 1907	3280a
	30—Data abstracted from results of 76 observations on harbor deposits, &c.	3280c
	31—Data, statements of tests, &c.	3270
	44—Report of Chief Engineer to Soper, October 28, 1908	3361
	54—Report, Allen to Soper, November 19, 1908	3369
	57—Report, Allen to Soper, November 9, 1908	3375
	67—Report, Allen to Soper, February 18, 1909	3381
	69—Report, Allen to Soper, February 13, 1909	3385
	80—Diagram of New York Harbor	3397

Page.

Complainants' Exhibits 89 and 90—Diagrams of surface current movements, &c. 3389

Complainants' Exhibit 91—Brief report on tidal actions in the harbor of New York, December 18, 1911, &c. 3391

92—Current observations near Robbins Reef, August 23, 1909, &c. 3425

93—Diagram 3446

94—Data, statements of tests, &c. 3448

95—Data, statements of tests, &c. 3651

96—Data, statements of bacterial tests, &c. 3708

97—Data, statements of dissolved oxygen tests, &c. 3778

98—Data, *In re* deposits from harbor bottom, &c. 3788

VOLUME IV.

THE PEOPLE OF THE STATE OF NEW YORK, Complainants,

vs.

STATE OF NEW JERSEY and PASSAIC VALLEY SEWERAGE COMMISSIONERS, Defendants.

EXHIBITS

COMPLAINANTS' EXHIBIT No. 1. James D. Maher, Commissioner.

Stenographer's Report of a Public Hearing Given by the New York Harbor Line Board, in the Army Building, New York City, December 9, 1908, in the Matter of the Application of the Passaic Valley Sewerage Commission for the Consent of the War Department for the Construction and Maintenance of a Trunk-outlet Sewer Beneath the Waters of Newark and New York Bays.

a *Index of Speakers.*

Messrs. Lebkuecher, pages 60, 85, 137, 230, 297, 303, 313.
Child, 10, 303, 314.
Harrison, 14, 150, 270.
Dean, 43, 86, 137, 138, 141, 150, 162, 214, 229.
Hering, 43, 233, 263, 297, 298, 300.
Dunn, 61.
Eastwood, 71.
Sherrard, 74.
Payne, 85.
McBride, 74.
Heck, 84.
Riker, 86, 105, 136, 138.
Higgins, 113.
Ring, 129.
Darlington, 104.
Miller, 88.
Porter, 97.
Conkling, 120.
Monk, 122.
Colyer, 129.
Parsons, 133, 196.
Landreth, 201.
Jackson, 162.
Ackerman, 229.
Kissam, 263.
Brush, 268.
Sandford, 293, 314.
Schondelmeier, 301.
Soper, 86, 89, 286, 300, 298.

Communications.

City Improvement Association, page 161.
Wallace Downey, page 160.
Atlantic Yacht Club (Bartow S. Weeks), page 159.
Sea Gate Association (Gherardi Davis), page 159.
Borough of Richmond (L. Tribus), page 148.
Calvin Tomkins, page 147.

Data.

U. S. Coast Survey Reports (Extracts), page 190.

1 Stenographer's report of a public hearing given by the New York Harbor Line Board in the Army Building, New York City, December 9, 1908, in the matter of the Application of the Passaic Valley Sewerage Commission for the consent of the War Department to the contruction and maintenance of a trunk outlet sewer beneath the waters of Newark and New York bays.

Present:

The New York Harbor Line Board, as follows:
Colonel D. W. Lockwood, Corps of Engineers,
Colonel E. H. Ruffner, " " "
Colonel John G. D. Knight, " " "
Lieut. Col. S. W. Roessler, " " "

The following gentlemen were also present:
Julius A. Lebruecher, Chairman of and representing the Passaic Valley Sewerage Commission.
Francis Child, Counsel for the Passaic Valley Sewerage Commission.
Edlow W. Harrison, Chief Engineer for the Passaic Valley Sewerage Commission.
Maurice B. Dean, Counsel representing the Attorney General of the State of New York.
Rudolph Hering, Civil and Sanitary Engineer, New York City.
Michael Dunn, Attorney, Paterson, N. J.
Poulteney Bigelow, Journalist, New York City.
Theodore Backers, representing the Attorney General of the State of New Jersey.
John H. Eastwood, Belleville, N. J.
Morris R. Sherrard, City Engineer, Newark, N. J.
2 Dr. Geo. A. Soper, President Metropolitan Sewerage Comm'n.
Gustave Schwab, New York City.
A. F. McBride, Mayor of Paterson, N. J.
J. C. Payne, Secretary and Engineer, Riparian Commission of New Jersey.
Mr. Heck, Board of Trade, Jersey City, N. J.
Chanler W. Riker, Counsel for the Passaic Valley Sewerage Commission.
A. Foster Higgins, representing the Chamber of Commerce, of New York City.
B. L. Stowe, representing Jersey City Board of Trade.
Anderson Price, Attorney at Law, New York City,—residing at Paterson, N. J.
Welding Ring, President, New York Produce Exchange.
Dr. Thomas Darlington, Commissioner of Health, New York City.
Hugh Gordon Miller, representing the Attorney General of the United States, in the case.

Joseph Coult, Newark, N. J.
Dr. Eugene H. Porter, State Commissioner of Health, New York.
Alfred E. Ommen, representing the West End Association, New York City.
Alfred R. Conkling, President, Realty League, New York City.
John Monk, New York City.
J. T. Colyer, New York City.
Captain Parsons, Maritime Association, New York City.
Prof. Olin H. Landreth, Sanitary Expert.
Dr. Daniel D. Jackson, Sanitary Expert.
William S. Ackerman, Member, Passaic Valley Sewerage Commission.
Coleman E. Kissam, Mayor, representing the City of Orange, New Jersey.
Dr. George W. Brush, President of the Brooklyn League, Brooklyn, New York.
3 Arthur Sandford, Contractor, Newark, N. J.
Dr. C. T. Schondelmeier, representing the Broadway and Allied Press Trade, Brooklyn, N. Y.

The Chairman: Gentlemen, if you will come to order, I will state the objects of this hearing.
The hearing is called, subject to the following notice:

"United States Harbor Line Board for Harbor of New York and Adjacent Waters.

ARMY BUILDING,
NEW YORK CITY, November 14, 1908.

1. Under the Laws of the State of New Jersey, the Passaic Valley Sewerage Commission propose to intercept the sewage from the district now discharging into the Passaic River below the Great Falls at Paterson and the tributary district which may hereafter discharge into said river, and convey it beneath the waters of New York and Newark Bays by means of a trunk outlet sewer ending near Robbins Reef in Upper New York Bay.

2. Application has been made to the Secretary of War by the Passaic Valley Sewerage Commission for the consent of the War Department to the construction and maintenance of such sewer, and the matter has been referred to the U. S. Harbor Line Board for the Harbor of New York and its adjacent waters for a comprehensive report on this entire subject.

3. The Board will give a Public Hearing on this subject in the Army Building, No. 39 Whitehall Street, New York City, at 10 a. m. on Wednesday, December 9, 1908, which you are in-
4 vited to attend.

Very respectfully,

D. W. LOCKWOOD,
Colonel, Corps of Engineers, Senior Member of Board."

The Chairman: The original papers in this case are as follows:

"WASHINGTON, D. C., Oct. 6, 1908.

Hon. Luke E. Wright, Sec'ty of War.

DEAR SIR: I herewith hand you on behalf of my client, the Passaic Valley Sewerage Commissioners, application for consent of your department to the construction and maintenance of an outlet sewer beneath the waters of New York and Newark Bay, as fully described and shown by plans on said application.

As required by the regulations, I have also furnished two extra copies of the plan annexed to the application and also a copy of the opinions of Gener'l Henry M. Robert and other consulting Engineers on the matter as expressed in an official report made by the Commissioners to the Governor of the State of New Jersey, June 1903.

I shall be pleased to furnish the Department with any other available data desired in the proper consideration of this application.

Respectfully yours,

EDLOW W. HARRISON,
Engineer, Passaic Valley Sewerage Commission, Jersey City, N. J."

5 The Chairman: These papers were forwarded to the Harbor Line Board by the following endorsement: "War Department, Office of the Chief of Engineers, Washington, October 13, 1908.

1. Respectfully referred to Col. D. W. Lockwood, Corps of Engineers, for report by the New York Harbor Line Board.

2. It is the desire of the Chief of Engineers that in considering this subject the Board give consideration not only to the interests of navigation, but also to the interests for whose benefit this work is proposed. In other words, it is desired that the report of the Board cover the entire subject in comprehensive manner.

3. An expression of opinion is desired as to the practicability of requiring the builders of this sewage disposal system to remove by dredging any deposit in navigable waters caused by the projected works.

FREDERIC V. ABBOT,
Acting Chief of Engineers."

The Chairman: The application to the Secretary of War, upon which this hearing is based, is as follows:

To the Honorable Luke E. Wright, Secretary of War of the United States of America:

Respectfully represent the Passaic Valley Sewerage Commissioners acting under authority of Chapter 10 of the Laws of 1907 of the State of New Jersey entitled:

An act to provide for the purification of the waters of the Pas-

saic River within the Passaic Valley Sewerage District prohibiting the discharge of sewage or other polluting matter into said portion of said river after a fixed date, and authorizing municipalities
6 lying in whole or in part within the Passaic Valley Sewerage District, from the territory of which sewage or other polluting matter is or may be discharged into said portion of said river, to enter into contracts with each other and with the Passaic Valley Sewerage Commissioners for the intercepting and disposal of such sewage and other polluting matter, and to provide the necessary funds therefor.

Propose to intercept the sewage from the district now discharging into the Passaic River below the Great Falls at Paterson, and the tributary district which may hereafter discharge into said river, and by the course of said river and Newark Bay and Kill von Kull now reaches the Bay of New York; and convey said sewage by means of a trunk outlet sewer extending from Paterson to a point of discharge in the waters of New York Bay East of Robbins Reef at a depth of not less than 40 ft. below the mean high water in said Bay.

The proposed alignment and grade of said outlet sewer, from the Westerly side of Newark Bay to the outfall into New York Bay, are as shown on the map and profile attached, and may be further described as follows:

The sewer will be in tunnel from a point West of the Western shore-line of Newark Bay, passing under Newark Bay, the upland of Bergen Neck, and under New York Bay on a line passing as near as may be practicable to the Light House on Robbins Reef to a point where the tunnel intersects the rock contour of the bottom of New York Bay.

At no point in the line beneath the navigable waters of
7 the United States and outside of the established line for solid filling, will any part of such permanent structure, when completed, be less than 35 ft. below mean high water except upon the reef of rock North of and not more than 500 ft. from Robins Reef Lighthouse where it is proposed to place a permanent shaft and shaft-house, rising to a height not more than 20 ft. above mean high water.

The point designated for said permanent shaft on Robbins Reef will be preferably where the rock approaches nearest to the surface, and consequently beyond the limits of safe navigation.

The tunnel will have an inside diameter of 12 ft. At the Eastern end, where the rock contour is intersected, four or more pipes of cast iron or reinforced concrete of diameters varying from 6 to 2 ft. will be laid in trenches on the bottom of the Bay to such distances (within the limits of the State of New Jersey) in any direction as may be deemed necessary to procure a quick and free dispersion and mixture of the sewage with a large volume of Bay water.

The pipes will be provided with proper openings along their length so that the total volume of sewage discharge may be broken up in units of volume so small as to be quickly dispersed and diluted with a large volume of Bay water.

No discharge opening will be less than 40 ft. below mean high water.

The discharge of sewage through said sewer at present will be from a population of about 600,000 people or practically 10% of the total discharge of sewage into the Bay of New York from
8 the surrounding communities, including the territory to be served by the proposed sewer. The ultimate capacity of the sewer is computed to be for a population of 1,650,000 estimated to be reached in 1940, and it is contemplated will not at that time exceed the present proportion of 10% of the total sewerage tributary to New York Bay. It is proposed to subject the sewage to a process of thorough screening to remove matter carried in suspension, and also to provide for the sedimentation and removal of sand and grit, at the pumping station in the Newark Meadows, before allowing the sewage to enter the outfall tunnel.

The undersigned Commissioners respectfully request that the following works may be authorized, approved and permitted so far as they come within the jurisdiction and supervision of the War Department:

First. The construction and permanent maintenance of tunnels under navigable waters of Newark Bay and New York Bay, as shown by the plans attached.

Second. The construction, laying and permanent maintenance of four or more outlet pipes of a diameter varying from 6 ft. to 2 ft. in trenches beneath the navigable waters of New York Bay within the territory of the State of New Jersey, and not less than 40 ft. below the mean high water, as shown by the plans attached.

Third. Construction and permanent maintenance of a shart, and shart-house upon the rock of Robbins Reef not exceeding 100 ft. square, and not exceeding 20 ft. in height above high water.
9 The site of said shaft to be determined so as not to interfere with navigation, and not to be inconsistent with the proper uses of Robbins Reef for lighthouse purposes.

Fourth. The temporary erection and use, during construction, of such cribs as may be required for construction shafts in the navigable waters of Newark Bay and New York Bay West of Robbins Reef and outside the established lines for solid filling. The said construction to be located, built and maintained to the satisfaction of the United States authorities having supervision of said waters, and to be removed on the completion of construction.

Fifth. Permission to erect and maintain such temporary platforms, floats or other structures within navigable waters as may be required for the purpose of sounding and boring to determine the character of the bottom. The said structures to be located, built and maintained to the satisfaction of the United States authorities having supervision of said waters.

All work, in or below navigable waters, both permanent and

temporary, to be subject to the approval and supervision of the United States authority having jurisdiction over the said waters.

(Signed) J. A. LEBKUECHER,
FRANCIS CHILD,
W. S. A. KERMAN,
Passaic Valley Sewerage Commissioners.

Attest:
JOHN S. GIBSON, *Clerk.*

Dated, Newark, N. J., September 23, 1908."

10 The Chairman: The Board will listen to the parties in interest, in the following order: First, the applicants, the Passaic Valley Sewerage Commission; Second, others who favor the project; Third, the Metropolitan Sewerage Commission and the New York Board of Health; Fourth, the navigation interests, as to the effect of the work proposed, in possible deposits in the navigable waters in question; and, Fifth, the Attorney General of the State of New York, represented by Mr. Dean, attorney at law, on the subject of pollution,—respresentatives of organizations, and individual interests, with regard to the subject of pollution. It is desired that any one addressing the Board shall come forward and first state their names, and speak distinctly, so that the stenographer can hear them. It is also desired that, as far as possible, the various interests will be represented by but one speaker, if that can be done. The Board will now hear the applicants in this case.

Mr. Francis Child (Member of the Passaic Valley Sewerage Commission): Gentlemen, the duty of presenting the questions relating to the engineering features, and matters perchance of most moment, to you gentlemen, will devolve upon our Chief Engineer who from long association with the work, has become perfectly familiar with all its details. Speaking for the Commission, I have this to say:

The lamentable conditions of the Passaic River on account of its filth, have been such, and is such, that, for the last eleven years the subject of some feasible project for the cleansing of the River
11 has agitated the public mind. That the Passaic River is now, and has been for years past, little more than an open sewer, cannot be contested by any one, for the very simple reason that it requires only the olfactory sense of any person visiting that locality to discover that fact. The stench arising from the river is such that property lying along its banks, both on the East and West banks, or above, on the North or South banks, has been so seriously affected that its saleability has been almost destroyed, for factory purposes and, when used for factory purposes, as I myself have heard gentlemen at the head of those great manufacturing industries state again and again, that the stench arising from the river, particularly during the summer months, was so great that their employes, particularly the female employes—and there are a great many women employed in those various factories—was so seriously affected that many of them had abandoned the locality, and others

were seriously ill. These facts none can controvert; indeed, I understand, they are all admitted.

The water of the Passaic River is black; it is black with pollution. Owing to a peculiarity of the river, which may, or may not be known to you gentlemen, in its winding course, and in the tidal effect, a curious phenomenon takes place. The sewage which leaves the upper waters of the Passaic Valley Sewerage District, that is, at Paterson, as has been ascertained, occupy eleven days at times, sometimes even more than that, and other times less, before they are finally discharged from the river. This is owing to an oscillation, resulting from the winding character of the river, and the
12 action of the tidal currents. A little gain is made each day in the downward course of the sewage, which is only overcome to a certain extent, perhaps a large extent by the out-going tide, and then the sewage is driven back, so that, in this prism we have sewage of eleven days that has been confined there, oscillating backwards and forwards, and with the limited supply of fresh water mingling with it, this great mass of putrescent matter has been there for a period of ten or eleven days. Now, these are facts; there is no guesswork about it; it is the result of experiments. Every measure that could be suggested, offering any reasonable grounds of relief, has been investigated. Every thing, septic tanks, and all the modern improvements of science have been investigated and every one of them has been found unavailable. The reason of it is this: That we have in the Passaic Valley Sewerage District—we have twenty municipalities; you can see that, in order to establish a septic tank system one of two things would be necessary: Either the construction of a great intercepting or trunk sewer, which would gather the sewage at any and all places, and thereafter give the sewage septic treatment or such other treatment as research might show to be best. That is not feasible for the very simple reason that the ground for that work cannot be obtained. Individual municipal treatment is impossible for the same reason. I do not know whether you gentlemen are familiar or not with the locality embraced within the Passaic Valley Sewerage District, but you take, for instance, the
13 municipality after municipality that is so closely connected with the City of Newark, that when you leave the one, here, you can hardly tell when you enter the other, there, these municipalities being, in fact, practically suburbs of the City of Newark, and so it stands to reason that the only method left for us, the only thing we can discover after a research of over eleven years, and examinations and investigations by four successive boards or commissions, aided by the best engineering talent in the country—the only solution we can find, gentlemen, is the solution which is now proposed to you gentlemen, and which will be explained at length and, I trust, in a most satisfactory manner, by our Engineer, who is not only a good engineer, but has the advantage—from long association, of being perfectly familiar with this territory,—with the tidal action and other matters of great interest.

I would now merely call the attention of this Board to the fact that it is not the intention of the Passaic Valley Sewerage Commis-

sion to put into the Bay of New York one more—one additional drop of sewage. Everything which we propose to handle under this project is everything that goes into the Bay to-day, and has been going into the Bay since a time when the memory of man runneth not to the contrary. It has always been done. It goes in in the most offensive form; it goes in after being held back for a period varying from ten to more days. It is proposed—we propose to take this sewage,—remove from it all effluence which is objectionable to the eye; all that which floats,—all that which is offensive and
14 that which will offer any unsightly appearance in the water.

We propose to receive this in a large receptable—to lift it there by pumps and send it through a set of tunnels and then, after it reaches its outfall, after being completely screened and everything objectionable removed from it, nothing but liquid—then to discharge it—not from a twelve foot sewer—not from a twelve foot sewer—and you will see the plan which you have before you does not indicate any such thing as that—but to discharge it by means of as many separate pipes as may be necessary—to discharge it so that I think I can speak within reason, that unless—and this is proven by our own experiments—unless a person was informed of the fact that a sewer was discharging forty or more feet below the ground, they would not be conscious of its presence. That is all we say, and as we have reason to say, that this is the greatest reduction—as far as we can ascertain—that has ever been made in the question of sewage disposal. We discharge it through as many pipes as may be necessary, in deep water, distributed over a large area, after careful screening and sedimentation; what more can be done? That we conform to the requirements of the United States statute, of course, is known to you.

I will now present to you Mr. Edlow W. Harrison, and after he speaks, Mr. Rudolph Hering will be prepared to answer any questions which you gentlemen may suggest.

Mr. Harrison: Colonel, and Gentlemen of the Board, I will briefly state the engineering facts which we find are involved in this
15 question, and am prepared at the same time to state the bases of our conclusions as to the entire practicability and availability of the project, and will endeavor to answer such questions as you may desire to put, although Mr. Hering, who follows me, will answer all questions you may desire to ask in this connection.

First, I want to say a word or two, in a little more technical way, as to the methods by which this sewage now reaches the Bay of New York. The sewage which we propose to treat,—the sewage of the Passaic Valley, which is gathered from the towns on either side of that Valley, commencing with Paterson, at the foot of the Great Falls, down to the Southern boundary of Newark,—at Newark Bay.

The Passaic River, in the three or four months of the ordinary Summer of an ordinary year, running from perhaps the beginning of July, to the end of October, has a flow, a natural flow, of not over four hundred and twenty million gallons a day; rather less than that than more. The Passaic River, in an ordinary flood, has a flow of from seven thousand to eight thousand cubic feet per second, or from

five thousand to six thousand million gallons a day. Now, into this River, in the Summer months, with a flow of four hundred million gallons a day we throw the sewage from a population of some six hundred thousand people,—or about sixty million gallons, which is at the rate of a hundred gallons per head per day,—and I think it is right to use the standard of one hundred gallons per head, which is about the water use of the community. We throw sixty
16 million gallons of what I will call standard sewage. Standard sewage, in the ordinary American community—in some communities it is stronger and in some communities it is weaker than in other communities, but to take the average as a standard, the sewage of the Passaic Valley Sewerage District is no stronger per unit, and no weaker, compared to a similar standard, and we are ready to prove it.

The tide flow of the Passaic is weak during the four months of the Summer The tidal flow of the Passaic is peculiar during the four months of the Winter, or rainy season—the rainy months. The tide, coming in from the narrows of Newark Bay, meets the fresh water flow of the River from near its mouth; that is, the tidal prism, so to say, is filled with the fresh water from the upper stream, and rises, with the stream, to the salt water dam below. That is the condition during the rainy months.

In the Summer four months, the tidal flow of the River reaches practically to the village or City of Passaic ten or twelve miles above Newark and where the river is about six feet deep and four hundred to five hundred feet wide. A very small stream. Now, the river is narrow; the tidal prism is small, comparatively, to the amount of drainage drained on either side, and the amount of sewage coming in.

Now, during the Summer months, with the sixty million gallons total of sewage coming in, it takes, if a man may state it, from four to eleven days before the sewage deposited in the upper river reaches the Bay—Newark Bay. This accumulation starts after a
17 rain, and commences to accumulate, so that at the end of a dry period, there are some eleven days' sewage in the river, and an analysis of the river water shows that that is about the fact: That is, that the Passaic River, at the end of a dry period, from Market Street, Newark—that is at the Pennsylvania Railroad station in Newark, all the way up in its tidal course, to Passaic, which is about twelve miles, contains now, in the Summer months, somewhat more of a bacteriological population than the Chicago River did before the efforts were made and the work of constructing the drainage canal was instituted. Now, during that time the sludge deposit is deposited in the river; along come the Fall rains, when, instead of having four hundred million gallons a day, we have, in fact, water enough to fill the prism several times over, and as I have suggested, we have, I would say, from five thousand to six thousand million gallons per day coming down the river,—rushing down in freshet. That is so. This deposit is taken into Newark Bay and there deposited, and you gentlemen of the Harbor

Line Board know who takes it out; the United States has to pay to take it out and dredge the channel of Newark Bay.

Now, as I have stated, all of these facts prove the material effect upon the property on either side of this river; it has been reduced in value. As for manufacturing purposes, it is not sought for. The people who manufacture there don't want to stay, and new people do not come. All of the people who have come into that territory, all of the purchases that have been made in that
18 particular section of New Jersey in the last few years have been based on the idea that this Commission was hard at work and that a remedy would be evolved in a short time; otherwise they would never think of purchasing, never think of building in the Passaic Valley. I can speak of several industries who have done that, and they have gone there with the belief that, in a short time, the State having taken it up, by this Commission this sewage matter having been taken up, the remedy would be found.

Now, you see, that the effect of this is,—the fiscal effect, not only to destroy to a great extent the commercial and the business interests of the Passaic Valley, and its real estate interests as a place of residence and business, but it is also destroying Newark Bay. They are building up Newark Bay. They are filling up Newark Bay. They are making Newark Bay into a septic tank for the deposit of this sewage, and that is affecting the whole community of four hundred thousand or five hundred thousand more people in the City of Bayonne—in other counties, who are not in this district who are complaining and who are here to-day complaining,—represented here to-day.

Now, I want to speak of a matter in this connection, because it is properly brought before you, which is,—we hear often of how this question can be taken care of by some of the modern ideas in regard to septic treatment and filtration. Now, we have considered it. The engineers who have charge of the largest filtration works
19 in the United States,—the engineers who have charge of the largest sewage works in the United States, have gone into this subject; they have written about it; you have had pamphlets in regard to that,—they are not considered as part of our case here, but this subject has been fully considered.

In the first place, we have not been able to find a suburban community of this size, spread out as this is and as it will be in the next forty years, where success has been made of the local treatment of sewage. We have examined and looked into practically every sewage plant in all civilized communities both here and abroad, but we have not yet been able to find a plant which we would dare to place in the center of this suburban district, thickly populated as this is, within seven miles of the City of New York, and, finally, we have not been able to find any plant but what within a certain distance, from one-quarter of a mile to a mile, or within that radius, odors have not been found.

We have not been able to find in this community, in New York, Staten Island, New Jersey, or around the territory adjacent to the Hudson, any community which was willing to have a sewage dis-

posal plant within their territory, and I do not blame them. I don't blame any sensible man for not wishing to have it. This whole territory is building up; it is thickly populated, as are all other territories around New York City. In order to take care of this water—this sewage, our opinion is that it will require one thousand acres, and if it was all taken care of by one plant, which would be the sensible way, if that way was adopted, we should have to take out of the area of the City of Newark, one thousand acres. Now, Newark has about eleven thousand acres In the Southern district of Newark is the great manufacturing and commercial city. The meadows at Newark which, for many years, were looked on as almost valueless, are now very valuable. The developments in the Newark Meadows in the way of manufacturing interests now amounts to hundreds of thousands of dollars, I might say, millions a year, and the future developments are tremendous in their possibilities; they are increasing now rapidly, and the developments now looked forward to are generally now expected will amount to many millions more. And the potentialities of the Passaic Valley is that with the aid of the Government, and with what work has already been done under the direction of your Board, that this Newark Bay, this lower estuary—this lower Passaic, the estuary of the Passaic at Hackensack will become, as with Newark, a large commercial tributary of the port of New York and form part of the port of New York Harbor, and grow side by side, together with New York. Now, we could not spare at Newark, one thousand acres. We could not put up a set of sprinkling filters in the area of one thousand acres taken up by the residence and commercial land of the City of Newark, and, two miles away, is the best part of Jersey City, and with Southwest winds, Jersey City would get the benefit of the sprinkling filters, and with Southeast winds, the City of Newark would get the benefit of the sprinkling filters; and, another most important point, in my idea is, that you will not find a sewage disposal plant anywhere but what the flies are innumerable and insufferable, millions of flies, and, with our present knowledge of sanitary affairs, we know that enormous quantities of flies would be dangerous in the vicinity of a large population. The only City that has tried that on a large scale is Berlin, and Berlin has fifteen hundred acres of sandy land for her sewage disposal plant—they do things differently in Germany——

Col. Ruffner: Did you say fifteen thousand acres?

Mr. Harrison: Fifteen hundred acres; that is, one thousand acres near the city, and public lands in the vicinity—the public lands altogether amount to fifteen hundred acres of sewage farms in the vicinity of Berlin; that is the case with the City of Berlin, but in none of the great harbors of the world, they have not there the great rush of waters we have here; the City of Berlin is far from the sea, and there was nothing else to be done, and even there, no citizen of Berlin, not a scholar, would be proud of the sewage disposal works, but being to a large part established under the well-known economic policy there.

Now, to cure this evil, this Commission, after a thorough study and after a number of the brightest of all our engineers have determined that the best disposition was the natural, first, disposal, due to our situation and to our being part of the harbor of New York, and to the magnificent advantage which this whole metropolitan district has, with the large flow of water and plenty of it, to take care of this project with safety, we finally decided
22 that the only, best, most economical and also the method in the line of improvement, future improvement, was to follow out somewhat the Boston method, somewhat the London method, somewhat more the Boston method, and with improvements.

Now, we propose to take that sewage down to the shore of Newark Bay, and there pass it through screens and sediment chambers, settling chambers, and remove from the sewage the heavy grit, all the floating particles, and, as you will perceive by our specifications which you have before you, we do not say just how much will be removed; we say "all that is necessary or shall be necessary" shall be removed, so that there will be no danger of an offense arising in the outlet.

Now, there is no question that we can do that. The City of Hamburg does it, there, with a population of over one million. They pass the sewage through a house there, through a house with settling chambers—over screens—the City of Hamburg passes the sewage through screens, then out into a settling tank or chamber eighty feet wide by thirty feet deep, after it passes through this chamber it passes through six sediment tanks, thence into towboats, for the sediment, and then discharged into the middle of the river, and the whole river traffic of the City, the ferryboat traffic and general river traffic passes over it; the main ferry station crosses the river, and excursion boat traffic with a station right over in front of the pump house and wharves in front of the pump house, and the Hamburg-American Line docks, about a mile or two
23 below, are right in the track of this sewer, and you cannot tell there is any sewer in there at all. The River Elbe——

Col. Ruffner: What is the rise and fall of the tide there?

Mr. Harrison: They have a rise and fall of about eight or ten feet, the result being that in order to save pumping they made their sewer so large, with their tide locks, that for four hours each tide the sewage flows up inside and fills up this very large sewer, much larger than ordinary, and they have, from my own knowledge, a great advantage, in the rise and fall of the tide, over what we have on our low level—we do not think it a great advantage, but they do that because it saves pumping, and then the gates open automatically, as the tide goes down and the flow goes out, there has been an accumulation by the intercepting of the flow, causing the sewage to back up in the sewer, which was made larger for this very purpose, which results in this sewage being locked into the large main sewer during the flood tide, so that practically sixteen hours' stuff has to be cared for on the ebb. Our project proposes a very large improvement over this method, as they have to provide for the accumulation

and have made the sewer larger than ordinary for the purpose; while we, however, will not have to hold this tide locked sewage. We improve a great deal, I think, on that; they have a very coarse screen, and the Hamburg sewage is heavy, is very heavy, it is very strong, probably twice as strong as the sewage in the vicinity of New York or in any of our cities.

24 Now, there has been a great misapprehension as to the amount of sewage—or a great misunderstanding, at least, as to the amount we propose to put into this trunk outlet sewer.

Now, I want to say to the Commission that the people of the Passaic Valley are no different than the people of the City of New York, and they do not furnish any more sewage per head than the people of New York; and this mistake may have arisen from the fact that a figure has been used in our descriptions, and in all good faith, fixing the maximum capacity of the sewer at 360,000,000 gallons per day ultimately; that is the ultimate capacity of the sewer, built to take for four or five or six hours, the peak capacity, the peak of the quantity of stuff which must pass through it; you all realize that at certain times of the day the flow of the sewage is much greater than at other times of the day of twenty-four hours, as in every community the same rule answers; now this figure is fixed as the peak of the flow, the maximum capacity of the sewer, three hundred and sixty million gallons; but the average capacity of discharge to-day is nearly—the average maximum discharge is only about two-thirds of that, or two hundred and fifty million gallons, and that is a capacity or average which we estimate will be effective around 1940; that, in other words, is the ultimate capacity. That will include, under the law under which we are acting, the house sewerage, a certain amount of ground water which cannot possibly be kept out of the sewer, and not more than ten per cent. of the trade waste, and when I say trade waste, I mean the total effluence from factories, much of it being clear water; the idea being that the operat-

25 ing of this sewer in a separate system, which is required in all communities, at times, the factory waste will be treated, as it is being treated at the present time and particularly as treated in other communities, and reduced by this treatment so that ninety per cent. of the water will pass right into the river, which, of course, will not injure the river at all. I believe, from our investigation—there have been investigations made in Paterson, N. J., by Mr. Hazen, there is no trouble about doing this; there is no difficulty whatever to do this.

Now, the present discharge is seventy million gallons of sewage; the maximum will be two hundred and fifty million gallons, and not two hundred and fifty million gallons of standard sewage, because the standard sewage — that will be the sewage from about one million and a half of people and the standard sewage of one and a half millions people would not be over one and a half millions gallons, and an additional one hundred millions would be made up of a large amount of ground water, and it is very necessary that there should be a large allowance made, because the Eastward slope of the Orange

mountains is of gravelly formation and contains enormous quantities of underground water.

Now, after this sewage is pumped up, it is sedimented and passed through screens, passed through a settling chamber, and then we propose to send it through a twelve foot channel running under this head, under pressure, the top of the tunnel being thirty feet be-
26 low mean high water; now, when I say not less than thirty feet, I mean, if it should be determined that we will go some twenty-eight or thirty feet below mean high water, it will be in the rock bed, in case you want to dredge where I call the Jersey Flats, the Jersey City flats, it will be in the rock bed, and hence no interference with navigation——

Col. Ruffner: What will be the depth of the top part of the sewer below mean high water as it crosses the Bay down there?

Mr. Harrison: The top line of the sewer will be below the water line—will be at an elevation minus fifty feet below; it must be remember- that in addition the sewer is twelve feet, lying on the bed of the Bay, or if it have a range from twelve to fourteen feet at the outfall, we might say thirty-six feet below low water——

Col. Knight: Below low water?

Mr. Harrison: Below high water. The plan was based on the idea that the requirements would not be over thirty feet below high water in the rock bed in Newark Bay——

Col. Knight: In the Bay?

Mr. Harrison: Yes; in the Bay, and also on the Jersey Flats between Robbins Reef and the Jersey shore; the Pennsylvania dredge is about twenty-five feet, the foundation for the new Pennsylvania yards is about twenty-five to thirty feet. Now, we probably will put that down even lower; the question of whether that tunnel in place shall be minus fifty feet or minus sixty feet has very little bearing upon the case. We may be able to find the rock and
27 follow it throughout the Bay by going down a few feet more. What we look for is a way for the tunnel: if the course can be better had down ten feet below minus fifty, I do not think there will be involved much more expense for the shaft, allowing us to keep within the shaft,—there will only be required a little more pressure there with the air; if we have to use air; I don't expect to have to use air only for a very short distance there.

Now, when we bring that out to Robbins Reef, where, in the vicinity of the light house there is now about, by our chart, five or six feet of water at low water, that is nine or ten feet at high water; and there,—or about there (indicating on map) we ask you for a shaft, and we ask you for the right to establish a tank or gate house in which we can control the flow from the tunnel into the discharge pipes although it is probably not absolutely necessary that we should have that; but it would be better for the project, better for the United States Government, better for all interests that there should be something there where the flow of these pipes could be controlled, and in order that they could be controlled in the flow; we would then be able to throw a larger velocity through any one of the pipes or in all of

them for cleaning out and scouring; also, in case of a repair to a pipe, we would be able to shut it off there without going into diver work.

You already have an obstruction to navigation on that reef; a Light House; the Reef was deeded by the State of New Jersey
28 to the United States, during the administration of Governor McClellan and the United States holds it for light house purposes; the State reserved in the deed the right of reversion *it* case it should be abandoned for lighthouse purposes and any use for any other purposes.

Of course, the Commission acts under authority of the State, and have the right to the use of any such reversionary interest of the State or rights of the State in any way. Now, I am well aware, the Commission is well aware, that probably the question of the location of this building—this structure is a small, common structure, architecturally—as it is contemplated to put upon this rock as a shaft and pump house—we know that the question of its location there on that reservation does not, I believe lie with the War Department, but that the final location would probably lie, we understand, with the Department of Commerce and Labor and as that Department requires; but the question of obstruction comes to you; that is the reason we apply to the War Department,—in regard to the obstruction. Now, if the Department of Commerce and Labor don't see fit—we think it should be as near the light house as possible,—in fact, my own opinion is that if we put up a proper kind of a structure the upper part of it could be used for light-house purposes instead of the small light house there as it is—the light-house there now is forty feet above high water; but, if the Department of Commerce & Labor don't consider that a proper place to put it, three hundred and fifty feet from the light-house we are in the lands of the State of New Jersey, and, therefore, we ask you for the right to put
29 it there on the same reef, about the same height or elevation, about the same part of the rock—we ask a right to put our shaft there.

Now, from this shaft and from this gate-house, which is practically the end of the tunnel, we propose to extend into the distributing ground, a series of perhaps four, we will say, four hundred four foot pipes; they will be rivetted; they may be rivetted steel, may be cast iron,—but we are not determined yet what will be the best use. They will, of course, have flexible joints. They will be laid in a shallow trench on the bed of the Bay. They will extend out to a depth of forty feet where there is water forty feet deep, on a forty foot paral-el/ line vertically below high water, and there we will commence to allow the sewage to go out, and we propose then to diminish the pipes across the channel, or into the channel, all within the limits of the State of New Jersey, sloping the fall of the pipes from 40 to 60 or 70 feet, and we propose to have openings in these pipes, in the several pipes, perhaps fifty or sixty openings, or as many as may be necessary, and the pipes, with these openings, will be distributed over as large an area as necessary so that every part of this filtered sewage, as it comes out from the pipes, will almost immediately be diluted with a proper proportion of Bay

water in order that the sewage may be thoroughly dispersed and that there shall be no offensive conditions arising.

Col. Knight: Do I understand that those pipes that you say you will have come down a slope—when you speak about sloping,
30 do you mean that the pipes will slope downward from the mouth of the tunnel for the length of the pipes, which you say is to be about 400 feet?

Mr. Harrison: When I spoke of sloping down, I referred to having the pipes slope downward toward the bottom of the bay, from a depth of forty feet to a depth of perhaps seventy feet, depending on the depth of the water.

Col. Knight: You propose to continue the pipes down to a depth of seventy feet, on a slope?

Mr. Harrison: They will be put at a depth of forty feet, and slope downward, with the several openings so distributed as to secure the best results in dispersion.

Now we do not limit ourselves in our specifications as to the practical plans; we do not limit ourselves, nor in the contracts which will be made with the municipalities under the law to how much that area of distribution will be or how many pipes may be necessary or how many openings may be necessary; we say we will give as many openings and over as wide a distributing area so that the volume of water in the Bay, flowing from forty feet to seventy feet deep will be sufficient to dilute the sewage as quickly as it comes and we put it out in small units to mix it at once with the water of the Bay. There we get the ideal practice. We get a great volume of water in the New York Bay; the great trouble in all sewage systems is the need of mixing quickly the sewage with the diluting water,—the oxidizing water. Now, in regard to that thing,
31 I want to give a few figures which are the result of our investigation and on which we base part of our argument; we believe and we know that they are correct.

And, first, I want to remind the Commission that the standard of dilution for Chicago was one to twenty; one part of sewage to twenty parts of lake water passing through; that is the standard,—one to twenty, or one unit—or four cubic feet per second of flow for each one thousand people—the ratio of the diluting water as to the population for the sewage——

Col. Knight: One moment; is the character of the Chicago sewage that you are going to refer to now, of the same character as will come from your effluence there?

Mr. Harrison: Well, leaving out the stock yards sewage, the character of the Chicago sewage is much stronger, as much of it is not screened——

Col. Knight: That is what I wanted to develop.

Mr. Harrison: Let me say, in regard to the screening proposed,—from the very best authorities, when we have screened sewage and when we have deposited we have thus reduced its pollution—its powers of pollution—power of offense so that the oxygen required to entirely destroy it is fifty-eight per cent of the normal; that is, if it takes one hundred per cent. of oxygen—that quantity of oxygen to

destroy the power of pollution of ordinary sewage, screened sewage, in the way we propose to put it through, as sedimented sewage, it is about 58 or 58 and a half—fifty-eight and a half per cent. of
32 oxygen will do it; that is, we practically take out about forty per cent of the putrifying substance. I give that on the authority of the English Royal Commission, Hall and Gibson, authorities on the subject.

Now, we will say that Chicago is as one to twenty;—Milwaukee is one to twenty-six,—in the improvement of the Milwaukee River. In the English Royal Commission, the result of their experiments show, as applied to American sewage, that it seems to be that the dilution of one part of sewage with fifty parts of ocean water—Bay water—salt water—sea water—one to fifty, with absolutely no knowledge whatever that anything was being put into the water—I mean that the sewage may be taken care of with no knowledge to the senses or to the observation that it was going into the water at all. I only give this as a sort of measure or scale by which to figure the figures we propose to give further on.

Now, from experiments we have made, only one or two, one which I happened to have right at my hand last night, an experiment made at ebb tide at Robbins Reef, in the Summer; we found at the surface eighty-eight and five-tenths per cent. of the normal quantity of oxygen in the Bay; that is, that the pollution first of the whole of New York, the whole of New York island, the City of New York, the pollution coming through the Kills and mingling with the waters of the Bay had not cut that oxygen down only eleven and a half per cent. Now the authorities are all agreed that water, as long as the oxygen is not cut more than fifty per cent. the sewage can be put into the river water
33 without offence to be taken care of. Of course, I am not making that as a statement of fact. I do not want to go too deep into this thing; I am only stating points upon which we base things. Now we find—at a point, you asked me in regard to the constituents of sewage. The speaker is asked for a comprehensive view of this. Perhaps I am going further than should be done, after having stated to you, and I am willing to prove it, that the sewage will be liquid; we propose to discharge liquid sewage into New York Bay; sedimented and screened, and under section 1307 of the River and Harbor Law, liquid sewage seems to be separated from the interdicted articles which are there legislated against being thrown into the bay or into United States waters.

Now, there is a question raised that the sewage of the Passaic Valley is particularly bad. That there is something in the sewage of the Passaic Valley, it has been alleged, different from other sewage; something that will rot timber, and tear out the bottoms of ships and things of that kind. Now, these are the facts, and these, presumably, because they are so manifest on the Passaic. Now, the facts are these: The population of the Passaic Valley as compared with the population of the rest of the district draining into New York Bay is as one to seven and six-tenths.

Col. Knight: One to seven and six-tenths?

Mr. Harrison: Yes; to the population of the one, the population of the other sections in this district is as one to seven and six-tenths.

Now, the manufacturing establishments liable to pollute the
34 streams, I have taken from the United States Census; the manufacturing establishments which are considered by scientific men—sanitary men—as those of a class which furnish large amounts of waste or polluting waste such as breweries, silk mills, dyeing establishments, leather tanning industries—I can give the whole list if necessary—any sanitary man would be able to pick those out at once himself,—they are in the ratio of one to sixteen as to number,—that is, for sixteen of such establishments in the territory including Hudson County, Jersey City, Hoboken and districts draining into New York Bay, direct, to one establishment on the Passaic. The capitalization is as one to seven; that is, our establishments are larger. The labor is as one to four. That is, we employ somewhat more labor. The value of the product is as one to seven; that is, the capitalization and the value of the product are practically the same—the product and the capitalization; the population, the labor, is a little heavier, we need a little larger number of laborers to an establishment in the Passaic Valley. The number of establishments are greater in New York, Brooklyn and the districts around the Bay, directly draining into the Bay, and there is nothing in that to bear out the idea that there should be any difference at all in the sewage. Now, those are the figures,—the statistics in regard to it.

Now, when we come to an examination of the sewage, and we have had hundreds of examinations of the Passaic River, and there has never been an examination which resulted in finding
35 anything different in Passaic sewage from the ordinary sewage of American cities, or New York, or the ordinary communities around here, except this, it is darker and it is thicker because our diluting water is so little. It goes into a stream of very little water. If you take a white boat up the Passaic River in Summer and you will probably have a black boat when you come back, but that can be cured by dilution.

Now, the next point in regard to that sewage, we propose,—the methods we propose are so very far in advance of anything that it is away and beyond anything that is being done now. You have this sewage, as the Jersey side of it comes off the Kills now. There is practically nothing comes down Arthur Kill; the current is down the Narrows into New York Bay.

Now, I had an analysis made of the waters of the Newark Bay on October 23rd of this last year; that was the end of the dry period—the waters of Newark Bay at the Central Railroad drawbridge, near Bergen Point, in the channel there, in the swiftest part of the channel, at ebb tide, towards the end of the ebb; the samples were taken and the analysis was made by Professor Stillman of Stevens Institute, and showed Free Ammonia seventy-seven-one-hundredths parts in a million; Albumenoid Ammonia seventy-four-hundredths parts in a million. The analysis of the Ammonia in New York Bay as made by the Pollution Commission of 1904 and

others made by the Commission on a New Water Supply for New York, showed the average of Free Ammonia, commencing at Pier One and running down in New York Bay as one hundred
36 and twenty-nine-thousandths of a million, and of the Albumenoid Ammonia, one hundred and forty-three-thousandths of a million. That is, on October 23rd, of this year, after this dry period, the result of the accumulation of sewage in the Passaic River and Newark Bay has made the discharge of waters of and from Newark Bay into New York Bay contain over six times a greater quantity of ammonia and amount of sewage than the normal waters of New York Bay. That is, the water that is going in now, from Newark Bay—going in *in* the *the* Summer—not now, because we have had rain,—the water that comes into the Bay in the end of the Summer from the Passaic River into New York Bay has nearly four, five or six times higher standard than the waters of New York Bay as determined by the Pollution Commission, and our figures, as determined by this Commission, and I must say the facts since ascertained seem to bear them out. That is, when the waters of the Passaic River, by way of the Newark Bay, strike New York Bay, it immediately reduces the conditions of New York Bay, and the reason for it is that that four or five or six times higher standard of ammonias which is accumulated coming down to the Bay shows its effect on the normal waters of the Bay, and notwithstanding this was the condition there through, a simple analysis it is indicated what an enormous purification is shown, and it shows that even lying there in that dry period, and without getting the benefit of that dilution which the volume of water in New York Bay provides, simply from purification, septic tank action, still when it got through from the Passaic through the Narrows, it has
37 twice—it has, not twice,—it has as much, ammonia per unit in Newark Bay as there is in New York Bay.

Now, that brings me to the condition of New York Bay as we take it: We find—the Chicago River standard—in purifying the Chicago River canal, the ammonias are due to that admixture, would be six hundred and ninety-seven-thousandths parts in a million of Free Ammonia, and one hundred and thirty-nine-thousandths parts in a million of Albumenoid Ammonia, that is, fresh, just as it comes in—of course, Free Ammonia passes into Albumenoid Ammonia in time. By this Chicago River standard, the Newark Bay had more free ammonia on October 23rd than the Chicago River has, purified. That is, Newark Bay has passed the line of four cubic feet per thousand. When it goes to the condition of fifty per cent. free ammonia, it will begin to give out an odor and may become a nuisance.

Newark Bay, away down to Bergen Point, with the pollution passing down to New York Bay, in only normally polluted by all the sewage of New York, one-fifth the Lake Michigan standard,—the standard of the Chicago River: That is, New York now, taking the sewage into it of five or six million people could take five or six times as much sewage, properly diluted, properly spread and properly brought into contact with the waters of the Bay, could take

five or six times the pollution it now receives before it reaches what every engineer in the United States pronounced the proper thing to be the best thing, for the City of Chicago, and also pronounced the most capable of taking care of the Chicago River so that
38 there should not be a nuisance arise. There, the point is this: We propose to put only one day's supply into the Bay. Each day by itself, that supply can be reduced,—of putrescent matter somewhere around forty percent. No more. Nothing to make a deposit. A liquid. We propose to deliver it over such an area that just as soon as it leaves the pipes it immediately comes in contact with a flow, of water in the large prism above, and in regard to that flow, of the tide in the prism, taking the map as it shows there (indicating), and allowing the sewage in there to be going out, as spread out at about an angle of sixty degrees and coming up like smoke, the water of that prism, moving along at the rate of one and five-tenths feet per second, which is about the average tidal flow in New York Bay,—the mean of the tidal flow, the tidal flow in that prism per second is sixty-three thousand cubic feet per second; that is, the prism above or across these pipes, flows at the rate of 63,000 cubic feet per second, and the discharge from the pipes,—the ultimate discharge, in 1940, our discharge then is two hundred and twenty-five feet per second,—the present discharge of it if in operation to-day would be one hundred and five cubic feet per second now, with sixty-three thousand cubic feet of tidal water per second to receive it.

One other point I want to make, and then I am through: The tidal volume, on the flood, in New York Bay, is said to be twelve thousand seven hundred and four million cubic feet, or about five hundred and ninety thousand cubic feet per second,— in six hours, twelve thousand, seven hundred and four thousand million
39 cubic feet in six hours, one flood. There has been a considerable discussion as to how much of that is sea water. Now, the New York Pollution Commission here referred to—they say they could not find it—now, I will ask them to look at their own report. They made a very careful examination and reported on the subject—that the bacteriological tests at a number of piers, commencing at pier No. 1, of the Iron Steamboat Company and going down to the Iron Pier at Coney Island—they started, the Commission started at the last hour of the ebb, on June 11th, presumably a warm day; they took bacteria tests at Pier No. 1, opposite Robbins Reef, Liberty Island, Gravesend Bay and in the Narrows. The report of the Board or Commission, in the first document they state they stayed there during the day and came back on the end of the flood, the last hour of the flood, in the afternoon. They took the same test of samples. The report of the Commission shows (Mr. Harrison is here referring piece-meal to the papers). The report of the Commission shows that they brought back fourteen and a half tests (they note the one-half test)—the report of the Commission shows they came back on the flood and they found one-half of the bacteria—just about one-third to one-half the quantity of

bacteria from the samples that they found when they went out on the ebb.

Now, during that day, they were away when New York Bay was tide-locked—they went down the last hour of the ebb, before the flood had closed the sewerage in—during the time it was tide-locked—the sewerage went out, one-sixth of the total
40 sewage in New York Bay, going into the Bay, bearing in it million of bacteria, the afternoon a warm one, in June, and the records of the Commission show that the water they took up was clear, clear, without stench, with practically plenty of oxygen in it; there was, also, a certain amount of Albumenoid Ammonia and Free Ammonia—(Referring to book—report—in making these remarks). That is all there (indicating)—increase in bacteria—whole afternoon—increase coming back—found only one-half the bacteria they found in the morning—at the end of the flood—all the day the bacteria had been pouring into the river and Bay from the sewers, and nothing going out.

What is the answer? What is the best answer, with one-half of a flood tide, at least, coming up? I submit that the tide that comes up is ocean water; there is no other change—one-half ocean water—I place no significance in the quantity of bacteria. Now, we will take the bacteria as so much aniline dye found here, let us suppose that they went out and placed a certain amount of color in the water, distributed in New York Bay at the end of the ebb tide, and came back, and found one-half, on the end of the flood tide. What is the fact? The clean ocean water came in up there, dispersing the color, cleansing the source.

They say their figures there were surface indications: They know well that under the surface of the water there is double the amount of salt water at a level of forty feet below the surface of the river, say at 39th Street, where, below the surface, and again at 44th Street,
41 at about 40 feet down, we have found twice as much salt water as at the surface. This water at the surface contains more of the albumenoid ammonia, more of the factory waste, more of the fresh water, while below the surface there is less factory waste and a larger amount of ocean water; fifty per cent. of that water, at least, which came in on the flood tide into New York Harbor, is ocean water.

Looking over the report, you will find no difference in the albumenoid ammonia, practically no difference over several years; you will find no difference whether ebb or flood; you will find very little difference in the bacteria found, or a reduction; and still the whole thing is, that the standard,—the standard of purity of New York Harbor, the standard and measure of what New York Harbor can do to sewage, it means that New York Harbor can now, and is now taking care of a population of six million, with a result in impurities, in the suspended impurities, of about one-fifth the standard which is accepted by all engineers and all sanitarians throughout the world as being perfectly safe. That is the standard, day and night, Winter and Summer. It may in Summer work do somewhat, but not in Winter. In their report (Referring again to papers) they

have shown some figures, that is that for four or five months of the year these waters draining into New York Harbor, and found in New York Harbor, have as much as thirteen-hundredths of a part to the million of ammonia. The standard which is safe runs up as high as seven and three-tenths of a part to the million. Chicago can go along with seven-tenths of a part to the million of free ammonia and a nuisance will not arise. In New York Harbor
42 the extreme has been thirteen-hundredths part to the million as compared with the germ condition incident to seven-tenths part to the million of free ammonia in Chicago, and this extreme in New York is taken from the surface of the water. If you will take all of the sewage in New York out of the pier end sewers, and take out of it all the matter in suspension, and put it into a liquid form, and bring the sewage right up through the water from the bottom, making an admixture all the way through, that condition will not be found. The trouble with New York is they should adopt this plan, we believe, of screening and sedimenting of the sewage, putting only liquid sewage in, and putting it in at the bottom, out of pipes with a large number of openings, so that the water, coming in contact with the liquid will quickly disperse it. If that plan is adopted and carried out for the whole city of New York, the Bay will take care of the sewage of forty or fifty million people, according to the engineers, who practically agree on that question.

Col. Knight: The application of your Commission before the Board now involves the question of sedimentation?

Mr. Harrison: It does.

Col. Knight: And of screening?

Mr. Harrison: It does.

Col. Knight: There is nothing before the Board to show how you propose to do that, nothing to show what your interpretation is of "such screening as may be necessary". Are you prepared to give us more details?
43 Mr. Harrison: I will leave that question to Mr. Hering.

Col. Knight: It will be adequately determined?

Mr. Harrison: Mr. Hering will answer you in respect to that.

Mr. Dean: I would like to ask some questions of the speakers, and would ask whether you consider it more convenient for me to ask them as each speaker concludes his remarks?

The Chairman: You will be allowed to question them at the end of the presentation of the petitioners' case.

Mr. Dean: I would like to have the petitioners state here certain information concerning the sedimentation and screening which is not set forth in their specifications and which we have been unable to obtain.

Col. Knight: I think it would make the matter briefer to have the questions come at the end.

Mr. Hering: I propose to be brief and merely refer to some of the essential matters in this proposition.

Some years ago, I was first brought into contact with this proposition by the State Sewerage Commission of New Jersey who had then under consideration the purification of the Passaic

River; and there were presented to the Commission of which I was a member, a number of plans contemplating the purification of the sewage of the different municipalities. We considered those reports and plans and propositions very carefully and we came to the
44 conclusion that in our opinion none of them would answer the purpose for the future, and we could not recommend any of them. So, then, the question was, what shall we recommend? and, after consultation, we made a new proposition to the State Sewerage Commission, and recommended the disposition of the sewage of the entire Passaic Valley, in a proper manner, into New York Bay near Robbins Reef, where the present Passaic Valley Sewerage Commission proposes to discharge the same.

At that time the methods of sewage purification had not developed as far as they have developed to-day; in fact, they have not reached perfection yet, and I think—having been myself three years ago in Europe, and this last Summer in Europe, where they are ahead of us in this particular branch of engineering.

We found that not only the expense of the individual purification schemes would be great, but we were afraid that as this population grew, it would encroach upon the territory which, unquestionably, is more or less offensive according to all methods that we have to-day, unless you provide a free territory around the same so that we felt that we had to give a positive recommendation, and I mentioned it.

Now, then, the question was to satisfy ourselves that that was the right thing to do, and that it was better than any of the other propositions that had been made. I had the honor again to be connected with this matter, as one of the engineers of the present commission, and had the instructions to revise the entire question as if
45 it was a new one, and see what could be done. That was particularly proper in view of the fact that the methods of sewage purification had unfolded and developed, and that the conclusion had was better than seven or ten years ago. Another study was made very carefully, and I also examined personally the various works in the world, Europe and here, with some of which I am connected,—and, again, the same conclusion was reached.

Even those modern methods of sewage purification, which are much cheaper than former methods and can be controlled better, and do not require so much territory set aside for them, have figured out more expensive than the present proposition and, in addition to that, they practically set aside an area, I believe, of about one hundred acres, or something like that, somewhere in the Newark Meadows, being the only available territory left for sewage purification,—set aside that territory, and it will never be an assurance, from our present knowledge, that it will not be objectionable within a certain radius around the Passaic.

Our provisional thought was that possibly a quarter of a square mile would practically have to be devoted to the project, or a reservation of perhaps more territory. These calculations were made on the very latest and best experience in Europe. We have only a few plants as yet in this country, in operation, on this latest,

best method. Small plants, too. Europe has had some for ten years, so that we know what it is going to do,—know what it does, and we can, therefore, when we compare the different sewages, and differing conditions, take them into consideration, we
46 can tell pretty nearly what they are going to do in this country; and all that information was utilized to test this question here for the Passaic Valley Sewerage Commission.

Therefore, the Bay disposal was again recommended, and is now, and I would like to say here why, and why it is better than the others.

You know, of course, that it means disposal by dilution, and the question is, what does that mean?

Some twenty years ago I was engaged by the City of Chicago to determine what that City should do with her sewage. Twenty-one years ago. They wanted to purify it, and yet that subject was one that was very doubtful in its effects and so on. Very large expense. They had an opportunity, which very few cities, if any other, has, of diluting their sewage and discharging it away from Lake Michigan, that is, into the Mississippi valley, and, therefore, preserve the water supply, which must be taken from Lake Michigan, there being no other available supply. Now, then, this canal which was to take the sewage, diluted, into the Mississippi Valley, went through rock for more than half of its distance; it was very expensive, and it was necessary to find out how large must you make that, because every inch in width would mean a great deal of money in added expense of installation; so that all the available information, from Europe and America was brought together to find out what effect *is there* by diluting the sewage, and, to be short, the result was that
47 a certain quantity of water, passing by and taking the sewage of a given population, will so dilute the same, and mix it and carry it off, so that the oxygen in the water will purify that sewage and render it, after a due time, not at once, but after a due time, render it innocuous.

Now, the figure, if I may state it, was three and one-third, about three and one-third cubic feet a second of flow was necessary to dilute the sewage for one thousand people. That was the result and on that basis the canal was built, and it is there to-day; and, now, what do we see in that canal? We see no pollution. We see that even though the dilution to-day is but two and two-thirds cubic feet per second per thousand persons, therefore less than the amount we specified, there is no offense, and that without question that big water way is going down from Chicago to the Mississippi River, and there is no offense. That is merely the result of data that was obtained from Europe, from Massachussets, and other places in this country at that time, which enabled the Commission to make the recommendation, and it has turned out as it was *accepted*.

Now, we have a great deal more enlightenment now on that subject, both from Europe and here, and I will say that the imperial government in Germany possessed a lot of cities on the rivers in Germany, who purified sewage, before discharging it into the rivers, but it was a very expensive operation, and the consequence was that

all of the cities got to work and found out how to purify
48 sewage, and the result was that they found it was practically impossible or, better, unnecessary. Reports were made to the imperial board of health and the imperial board of health changed its dictum and now desires that a certain amount of water must go down those rivers to dilute the sewage of a certain population. It has thrown away the Chicago standard, and for good reasons. But the sewage must all be screened and settled, but nothing more. Now, all the cities are doing that: Along the Elbe, along the Ader, along the Rhine, and other cities; that is, they are not all completed,—the works are not all done, but they are going on in that direction. This was not an unknown matter to some engineers, and, now, every engineer that has studied this matter and had some experience in it would say that that was the way the thing was going to go eventually, and that the imperial German board of health was executing something which was altogether too expensive and unnecessary at the present time.

For that reason, the specification for this Passaic Valley Sewerage District sewer was made so that the sewage shall be screened and then it shall be settled, because, the first Board, of the first Commission said: "If you want to put this sewage into New York Bay, do you want to put it in like Hoboken, like Jersey City, right along the shore, or, how? I said, personally, I do not think that that is proper, because it is all one grand metropolis, and I should suppose
that that would be very objectionable, in fact, I think every-
49 body would grant that it would be objectionable; therefore, I proposed the method that you have been told about, at the time. Better than Hoboken discharges its sewage; better than Jersey City discharges its sewage; better than New York City discharges her sewage.

Now, here are the chief differences, why I believe this is the best system of sewage disposal for the territory under consideration. In the first place, the sewage has all its floating matter taken away at the pumping station; in other words, the sewage is screened——

Col. Ruffner: Won't you please explain that to the Board?

Mr. Hering: I was just coming to it: The screening is done in a number of ways in Europe. We have got about a half-dozen different plants and screens, one particularly nice, I was looking at, this Summer, being from two millimeters to an inch, two millimeters is about one-sixteenth of an inch, and experiments have been made as to how much can be screened out and as to what cannot be screened out, and you will naturally see that by screening you can get out all the coarse, floating matter you do not wish in evidence, and we do not need any evidence about it, it seems to me that the chief objection we all find in the New York sewage, which is not screened out, we see it coming down, floating down both rivers; we see it, and we know it is sewage, and we don't like it; that is the reason for screening the sewage in Europe, almost everywhere, that is the reason we contract to screen it here, so that none of it will float down the water any more.

50 The next thing is that we take out the sediment, in order to prevent this sediment from depositing in the channel and

filling it up. This was done after a consultation with General Roberts and General Raymond, of the Army, and no details have been made as to just how much sedimentation should take place; but sufficient to satisfy whatever demand the United States Government may make. Now, that is proper, so that those two things are out. Then, thirdly, the sewage is not discharged at the shore, like that of Jersey City, or New York and Brooklyn, but nearly one mile from shore, and, for that reason, the effect of the New York sewage going down along the piers, which is taken up by the same thread of water, and where there is, an accumulation, instead of dispersion, does not take place,—it is out in the middle of the Bay, nearly a mile from the shore.

The next point is that the sawage is discharged forty feet below the surface. Now, that is a very important matter,—in fresh water, and, also, in salt water. You can readily see that when the sewage is discharged down, far below the surface that, as fresh water, it will rise in salt water, it will rise up towards the surface if left alone, and the surface gets quiescent, and it may be apparent there. This is so in Boston; it is so in many other cities where they discharge large bodies of sewage in salt water some distance below the surface. Now, I do not know of any place where it is discharged as much below the surface as it is intended to be here, nor in the way it is intended to be, and as it ought to be, but my experience, I will
51 say a litt'e experience I had in Honolulu helped me somewhat in this conclusion. The experience generally in Europe has, as elsewhere, shown that this sewage will be dispersed as it rises, the only question is, into how much water shall it go,—how much sewage into how much water, and, as a provisional only, I assume, for the case here, the same dilution that I recommended to Chicago, which is provisional, knowing very well that this is salt water and Lake Michigan is fresh water, but it gives a foundation, and I am not certain as to just what is the actual best dilution because there seems to be no careful investigation on that subject as yet, and it is not very simple or easy to make. For that reason, I suggested a number of small outlets,—think the number was four hundred small outlets, to be placed upon this sewer, across the current, so that the water, moving into the Hudson, and into the rivers and Bay and out, would pass those openings and take from each one an amount of water just about equal to that which renders the Chicago Sewage entirely inoffensive. Therefore, it was necessary to issue the sewage in small amounts in small pipes, across the current and, as the report which you have shows this method has been adopted by the present commission; it is a dispersion of the sewage better, I think, we may say, than in any other city in the world except possibly Hamburg; but that is a very small affair, and is not nearly so effective as this, although that is the best that could be done there.

In Hamburg, the sewage is screened and settled the same as here
and is discharged into the Elbe across the current just as
52 is proposed here, with a number of small openings just as is proposed here, although there, perhaps, not so thoroughly

worked out as may be done in this case under different and somewhat better conditions. There, what is the result? All of the Hamburg sewage goes out there; you don't see it at the surface; ships go back and forward over the place where, thirty feet down, the sewage is discharged, at a depth of thirty feet; all the vessels pass there and see no objectionable results in the water and the people are perfectly satisfied. The tide there is about six feet, it runs up and it runs down, but I don't know how many, perhaps ten, miles below this City, not more than ten miles below, in the current of the stream, the City of Albany, a large City, with a large population, takes its water supply out of the Elbe, into which the sewage of the City of Hamburg has passed under the conditions described, it takes its water supply, filters it, and, at the time when the cholera was in Hamburg, when the cholera sewage went right into the river, therefore was taken up by the intake of the Albano water works, yet there were no cases of cholera in Albano excepting those who drank water in Hamburg,—one of the most remarkable cases on record in the world; they drank that water, and they drink that water today, and they do not object to it, and they do not think of getting any other source.

Now, I believe, Mr. Chairman, that that is all I wanted to say about the method of sewage disposal, which I thoroughly believe is the best that can be made, and I only wish to say one
53 more thing: I hold the position of consulting engineer to the Board of Estimate and Apportionment of New York City and I would not for a moment allow myself to say a word which would in any way affect the best interests of New York City, and I believe that there is no way to dispose of the sewage of our neighbors that is better than the one that has been recommended.

Col. Knight: Will you kindly go a little more into detail as to the passage of this sewage backwards and forwards with the tide? How far down stream would it go from your effluent there?

Mr. Hering: It would, naturally, go as far as the water of the river would go during the incoming tide, and then it would go back and down as far as it would travel.

Col. Knight: Have you determined any limits in any of the reports you have submitted?

Mr. Hering: No limits of distance, because it don't seem to us to be very essential, for this reason: that the sewage is diluted, so that it is not feasible—I want to state one thing, please, which is a proof demonstrative—to demonstrate just what I say, some might say, oh, that is all very good reasoning, and perhaps a good deal of theory about it, and in these questions it is well to have a practical demonstration, so I urged that a practical test be made. The Commission consented, and we procured a barge containing about thirty thousand gallons of fresh water, and representing sewage, and so that we could see the same, we put into it enough red aniline
54 dye to make it blood red, so that you could see the coloring plainly, well it was just like blood. Now, we went down to the point where it is proposed to discharge this sewage, this side of Robins Reef, and at a time when the tide met,—that is, I wanted

to get there at such a time when the water was as quiet as possible, because then it is very clear, and it seemed to me that when the water ran from four to five feet per second you would not see it very far any way, so I wanted the water as quiet as possible. We therefore discharged this thirty thousand gallons of adulterated water at the time when the tide went least—the velocity was least, and we found as follows: We found that when it was discharged ten feet below the surface, you could very soon see this blood-red water at the surface; naturally, that could be expected; the fresh water came up; it was lighter than the salt water. Then we discharged it twenty feet below the surface and we had to wait some time, and then it came up, some of it, but very much dispersed and not so vivid. All the rest of the water we discharged at thirty feet depth and although we were around there over two hours we never saw anything at the surface at all, not a thing of this red liquid.

That was a very crude experiment; it was really intended only to see how it would act, in order to get some practical details, and so the Commission consented to making that test with the expectation of some day having a test made that might prove it more thoroughly so as to be able to say that with this Passaic
55 Valley sewage, discharged out of a six inch pipe at a proper depth, at presumably as nearly as possible the real conditions, and the quantity, the width of water which was to dilute it would be about the same as in this project, although the details have not been studied out, as there has been no opportunity for doing it. I merely want to say that this proved that this assumption is correct in practice as well as in theory, although I do want to say that was theory in a sense, not being actual sewage, but it is not speculation, because it is not—there is enough evidence given here as to the practice at Hamburg, Germany, as well as in our own country to remove that from any charge of speculation whatever.

Col. Knight: Another question, Mr. Hering: As to the proportion of solid matter in sewage, the proportion you will remove by screening; the proportion that will still remain subject to sedimentation?

Mr. Hering: The proportion which can be screened out varies, of course, with the size of the openings between the pores of the screen. Now, very elaborate experiments were made in the sewers of Berlin on the subject of screening and with different size mesh, and it was found, with the ordinary screen, going down to about a centimetre in opening—a centimetre is about a half inch, about a half inch opening in mesh you can get out more than fifteen per cent. of the suspended matter, but you get out everything that is larger than a half inch. The other suspended matter is very small and remains in the water; it is what renders the waters dark, but it is
56 so small,—the partices are so small that they cannot be seen as particles, their presence merely serving to darken the water.

More recently, experiments have been made with screens down to a still smaller size, down to a millimetre in the size of the pores, and, there, a much larger percentage was taken out, I believe about one-quarter, but the three-quarters remaining in the water corresponds in size and effect to what is in the water after a rain, causing the water

to look brownish; it is so small as to be almost impossible to screen out with any contrivance of this sort we have been describing; it has to be filtered out; but that would go through the screen, even down to a millimeter size of mesh; but there is nothing, that amounts to anything, in the sewage in a sewage system such as this we contemplate, that is not to take in, after it is completed, any storm water or any surface water, which is objectionable, all the larger particles, all that floats, has been taken out——

Col. Knight: You still have not touched the point, Mr. Hering, you commenced in one particular, but you have not developed it; my idea was to get your idea of the proportion of solids to the amount of sewage,—then the amounts removed by the different stages?

Mr. Hering: This is the figure we usually use; of course, our sewage is very much more dilute than that of Europe, and we must take that into account. We assume that there is one part of solids in five thousand parts of water, about. But the solids are very small; of course, everything that is solid is included in that.

57 But sewage, you know, consists of, we will say, organic matter and mineral matter in about even parts and, together, they only amount to about one, that is, to about three or four parts of water to one part of such matter in the sewage; that is the ordinary house sewage, in that composition.

Col. Knight: Of that, you will remove, by screens, then, fifteen to twenty-five per cent?

Mr. Hering: Yes; and that means, that we would remove one hundred per cent. of the matter that you would see floating.

Col. Knight: Then, what remains after the sedimentation? That would also take out a small part of the grit that screening had not?

Mr. Hering: That would take out the greater part of the grit that screening had not; that takes out the grit; whatever will deposit. Now, that is a subject that has not been studied yet very much——

Col. Knight: I noticed you leave it vague.

Mr. Hering: It is left vague because it takes a great deal of study and expense to find out those details; they simply have not been attacked yet; it was the understanding, of course, of the Commission, that whatever was necessary to be done would be done. Rough estimates have been made; I cannot tell you just what those rough estimates are, any more, but sufficient, I am quite sure, to cover whatever sediment would come in.

Col. Knight: And when the application is made for a per-

58 mit, it includes sedimentation, simply to include things that may arise and have not been accurately determined yet?

Mr. Hering: This quantity is not accurately determined yet, but the fact that sedimentation shall be there and the basins shall be large enough to allow the velocity to be small enough so that matter of a certain size will deposit,—that has all been determined. You are aware, perhaps, that the matter carried in suspension by water, given a certain velocity of the water, if you reduce the velocity, you cause the suspended matter to be deposited; it is an entirely fixed ratio.

Col. Knight: Well, the screening station here, the location of the

pumping station, is right on the edge of the water? (Referring to map.)

Mr. Hering: Yes.

Col. Knight: Now, where do you get any sedimentation basins—(referring to map) where are they to be arranged for between that point and the point of discharge?

Mr. Hering: It would be arranged above the pumping station—the screening and gravity basin would be above the pumping station——

Col. Knight: So, your screens and gravity basins are away down there (indicating on map)? They are supposed to be there (indicating) before you come to the pumping station?

Mr. Hering: Yes, sir.

59 Col. Knight: Now, just whereabout, in this route, whereabouts is that development—the commercial development that the City of Newark proposes—the Canal?

Mr. Hering: I cannot tell you that.

Col. Ruffner: I would like to ask you if you propose to do that small screening at all before you reach the pumping station, or only there?

Mr. Hering: Whatever screening is necessary and whatever disposition is necessary to facilitate the pumping that is to say, not to injure the pumps, will, of course, be done at local stations, and all that, of course, will again be screened at the pumping station.

Col. Ruffner: That is, you expect to do screening and sedimentation in each of those local stations, before you reach the pumping station, and there also?

Mr. Hering: Yes; the screening and sedimentation at the pumping station will, of course, be on account of the pumps.

Col. Knight: It has been determined at Hamburg—that question of sedimentation—that question has been practically put in use at Hamburg?

Mr. Hering: Yes, sir.

Col. Knight: Have you any idea as to the results?

Mr. Hering: Well, the results are very good, of course, they must dredge the rivers there; but, there is no complaint whatever that I could hear of that the sewage is silting up the channels there.

60 Col. Knight: But what do they remove? Do you know anything about the proportion removed by sedimentation?

Mr. Hering: I cannot remember. They have a very small settling basin there by screening all the large matter.

Col. Knight: That is all?

Mr. Hering: That is all I know. That is right at the screen. Right at the screen; the settling basin is only about as large as this room (about 80 by 20*) but the system is only for the City of Hamburg,—the plant is not very large. That is all. And they get out everything they think is necessary, and they are entirely satisfied with the results, and the shipping traffic which passes right over the discharge points makes no complaint, and seems to have cause for none.

Mr. Dean: Did I understand, Colonel Lockwood, that questions might be asked after the completed statements?

The Chairman: After each individual, yes.

Mr. Dean: I would like to ask some questions of Mr. Harrison, as to his statements, and of Mr. Hering, subsequently. I would like to go into the details of this project——

Mr. Lebkuecher: Mr. Chairman, might we not be first heard here? There are here a number of representatives from the Passaic Valley district, and we want to make a full expression of our case; many of them cannot remain here very long, and this questioning can come later, if you please.

61 The Chairman: I think that might be as well—what do you say, Mr. Dean?

Mr. Dean: It is entirely agreeable to me, provided the gentlemen whom I desire to question in order to obtain the details of this project can be detained to answer those questions subsequently?

The Chairman: Well, Mr. Lebkuecher, you can arrange that?

Mr. Lebkuecher: I understand Mr. Dean wishes to question Messrs. Harrison and Hering, and they will be here after the presentation of our case.

The Chairman: Well, then, you may proceed.

Mr. Dunn: I have been obliged to give this subject considerable attention, both as a property owner in the Passaic Valley, as a taxpayer in the Passaic Valley, and, as a lawyer, protecting our city of Paterson, as its counsel, from attacks which riparian owners below our city have found it necessary to make against the city in order to cause it to desist from further discharging the sewage into and polluting the waters of the Passaic River, and, in consequence of that, I have also had occasion to give considerable study to this subject in connection with the Passaic Valley Sewerage Commission, which was first organized in 1896 and, from that time down to the present time, I have been in close touch with all their investigations, and know the work that they have been engaged in.

Now, the principal point, is seems to me, in addition to what has been stated to your board by the engineers here, to which

62 attention should be called, is this: Why is it necessary that there should be an improvement of this kind in this Valley? and, who is it going to benefit?

Now, in the first place, I want to call your attention to the fact that in this Valley is represented one-third of the taxable ratables of the State of New Jersey. I want to call your attention to the fact, another important fact, that in this territory is represented one-third of the population of the whole State of New Jersey; and I want to call your attention to another fact,—that there is no piece of territory in the State of New Jersey to-day of such future, with such a promise, with such an outlook for development, that the Newark Bay, the property around Newark Bay and the Passaic Valley has if we can only get this relief for which we are now seeking consent from your Board. Now, the reason for that follows: The Passaic River is an open sewer, and it has been an open sewer, and, in consequence we must find some relief.

The City of Paterson, located as it is, at the upper end of this improvement, at the foot of the Great Falls, and the greater part of this City, its residential section and its factories, located along the River, as it winds through the City, is in such a situation to-day that we almost have to come to you appealing for help, for this reason: The character of our soil and the topography of our ground is such that there is no land South of our territory available, and we cannot go North because that is all up hill; there is no land lying
63 South of our City as it lies, there is no land South at all available or suitable for sewage disposal work; there is no land that we own East of the Passaic River, and that is in Bergen County and in foreign territory.

We have been annoyed for a considerable time by these riparian owners whose property was being disturbed, whose land was made unsalable principally because of the pollution we were discharging from our factories and sewers into this River, and in 1901 they started suit for an injunction against the City; we resisted and defended ourselves against the suit,—the litigation was prolonged in consequence of this question, whether Paterson should be responsible to riparian owners for the damage done to their property or for only such proportion as was done by the discharge of the factory waste and pollution through her sewers, the fact being that along the river there are thirty-seven factories, dye houses, silk mills, locomotive shops and so forth, giving employment to ten thousand men and which discharge their sewage directly into the river; so that was the main question, the main question of discovery before the Courts in that litigation was as to the proportion of damage, and which has just resulted in a decree by Vice-Chancellor Stevens compelling us to pay a sum amounting in round numbers in damages and costs, to Thirty thousand dollars; in addition to that we have spent in the neighborhood of Twenty thousand dollars in protecting and defending ourselves; and that injunction is against us, to take effect by March 26th, 1911, that unless Paterson by that time
64 makes an honest effort in finding a way to dispose of the sewage by March 26th, 1911, that injunction will issue, and unless the court of equity for good reason believe that such an honest effort has been made as in equitable terms may be so deemed, then and in that event the City of Paterson will be liable to the riparian owners in damages and compensation may be given and relief granted, so that we are now under mandate of the Court of Chancery to get that sewage out of these waters and cease polluting these waters by March 26th, 1911.

Now what else is our position The act of legislature which established the Passaic Valley Sewerage Commission, creating it, and which has come before your Board with an application for the best, and only system for purifying this water, under which this application is now made to your Board, that act provided that on December 12th, 1912, all persons polluting the Passaic River from Newark Bay up to the Great Falls should cease, and above the Great Falls the Passaic River or its tributaries, so that we have been informed by the Passaic Valley Sewerage Commission under that act that we

act within these provisions, so that even if the Court of Chancery should grant us an indulgence after March 26th, 1911, we would still be under the ban of that act, we would still be under the ban of both the courts and the sewerage commission, forcing us to get out of the river.

In addition to that, following along the banks of this river
65 is some of the most valuable and desirable property anywheres in the land is located, convenient for transportation, for factories, if we could do what the City of Passaic has been able to do for years, and we have not. Paterson has not been able to get new industries into the City because we have never had a place where their people and the factories could discharge their sewage their effluence without being liable to suits from lower riparian owners, so that the Passaic people have been able to get in more right along, and another important plant has just been located there, to cost a million and a half and to employ three thousand hands. But since Paterson has consented to unite with this Passaic Valley Sewerage Commission, what has happened to us? Right here, across River Street bridge, right at this point (indicating on map) there has been projected and is now being built a factory to give employment to five hundred men, the factory costing Four hundred thousand dollars, but this undertaking was located in our City with the precise understanding that we are to be able to get the consent of the Commission—the Passaic Valley Sewerage Commission that they be permitted to discharge their sewage—their effluence into the sewers.

I am speaking of this merely as an example illustrating the great future there will be for this district once we get a place where objectionable effluence can be discharged into this sewer without doing harm to the lower riparian owners. Now, why we should not have this future I cannot understand. There is Newark being permitted to develop all this territory in here (indicating on map).
66 Why, just take New York as it is now and as it has been in our time, and see how it has developed: You will remember the time here, fifteen years ago, you could readily buy practically all the land you wanted, the upland here (indicating on map) for a song, now the price of land of every kind has gone up so that you cannot buy it to-day, you can get a lease, or take more than you want to put into it, and coming down along Newark Bay here (indicating) you can hardly get dockage.

What is proposed here is to improve the great territory lying around Newark, available and suitable for such purposes. Here is Newark, with all her thousands of acres of land here (indicating) kept undeveloped. Why, I have been informed that at the Clark Thread Works, the stench from the river is such in warm weather that they have had to allow their employes to go home, although they have kept the windows closed on warm days. And at Passaic, in the filtration works, Mr. Gardiner, of the Water Company, has told me that the stench is such in the afternoons that they had to close down the works.

Now, then, we ask you if, in view of these facts, in view of the

fact that here is the city of Paterson obliged to pay Thirty thousand dollars in damages to those riparian owners because their property has been made unsalable, because sickness and ill-health has been produced in families and children, as testimony adduced there proved, because other people down along this shore are complaining of this nuisance, can it be said that this great benefit should be withheld from this great valley?

67 Now, then, another point that I think probably it would not be improper for me to make adversion to.

I understand that there are some people in the State of New York who entertain the opinion that they ought to object to this improvement—who have entertained the notion that this improvement ought to be objected to; just why, I do not know. We are neighbors and we should be neighborly, but there is an impression among certain men that they always ought to be appearing as objectors to any improvement going on.

Now, it seems to me that they ought not to take New York City, Brooklyn,—Greater New York as a pattern and come before this Board, representing the Federal Government, and make an objection to an improvement which means so much to the public health of all of our State, and which means so much to the industrial development of the territory there when they stand right here discharging raw sewage and street sewage right into the waters of the Bay.

But they say, "Oh, well, you ceded to the State of New York, the right to exercise dominion over the waters of this Bay and the waters of New York Harbor, and, therefore, New York people, and those who are responsible, are entering complaint, and you must come and consult them before you can build an improvement of that kind in the Bay". Now, in a word, to answer these objections, let me simply say this: I have given considerable study, careful study and investigation to those suggestions, and, in the first place, I say that

68 the position which the State of New York takes upon the question of nuisance is settled by the case of the State of Missouri against the State of Illinois in the case of the Chicago Drainage Canal. The Supreme Court of the United States has just rendered a decision and has said to the State of Missouri, "so long as you and your cities continue to pollute the waters of the Mississippi River, you do not stand in court with clean hands and until such time as you can prove that the evil of which you are complaining is produced alone by the Chicago Drainage Canal, you have no standing in equity."

Now, where does the State of New York stand, in equity, with clean, or dirty, hands, in making an application against New Jersey, for an injunction against the State of New Jersey, because it may happen to pollute the waters of the Bay, according to our engineers not in a lifetime, not in the lifetime of any of us and not in centuries with the present growth of population, will the Bay be incapable of taking care of the sewage from the population, as stated by Mr. Hering, and which all engineers have conceded is correct. So that, they will say to the State of New York that it is premature in trying

to have the Supreme Court of the United States imagine there is a nuisance there, of which they cannot adduce any proof.

The City of Newark applied for an injunction against the City of Passaic, in 1882; they wanted to build a sewer system in 1882, and the City of Newark was getting its water supply there and she very properly thought that when the City of Passaic, with sewerage from a population of thirty thousand, would render the water unfit by
69 pollution. Now, what did she do? She went into the Court of Chancery and asked the court of chancery to grant an injunction, but the Court said, "no; that is not a principle of equity to enter an injunction in the case until such time as you prove the nuisance, until the injury is shown, we will hold off our hands and if, after such a time if it is found they are committing a nuisance there and do not abate it or modify it so that it ceases to be a nuisance, then the Court may act." So that the same principle invoked by the New Jersey court is applicable to the case here.

Just a word more: In saying that this great amount of money should be applied—the City of Paterson, in order not to be tied fast to any proposals of this very Commission and their very able engineers,—there was a feeling among our people that the cost of our apportionment of over Two million dollars was very heavy, considering that our total ratables at that time were fifty-eight thousand, although more now, being some ninety-two thousand,—that apportionment was made also seven years ago, and it was simply submitted to our people as a basis to work on, and the feeling was that every effort should be made to secure the very best results for the amount involved, and so we had Mr. Allen Hazen make a study and investigation of this whole subject and recommend to that City what was in his judgment, what was the most feasible, economical and practical and effective plan to adopt, and he recommended—he had studied the whole subject, both in this country and abroad,
70 and he said that the plan which seemed to him as the one best plan was to erect a rock dam, across the river, in Dundee County and there install a sewage disposal plant, and he recommended that we immediately buy there five hundred acres of land and clear it up, right over the river here (indicating on map) South of this line, right in that (indicating) territory there which might be used for a disposal works. But there was no law in the State of New Jersey that permitted the City of Paterson or any other municipality to do this or allowed them to go out of their own territory and erect a disposal works. So, we went to the Legislature in the following Winter, and we presented to them the matter in full, including all of the recommendations, and the Legislature passed a law thus far: "We will grant to Paterson, or any municipality in New Jersey, permission to build a separate sewage disposal plant provided there be no objection on the part of the authorities in the territory in which the work is to be performed or from other persons having a right there at present."

We subsequently consulted with the authorities in Dundee County, and they said: "No, you cannot put up any out-house on our ground; we won't let you destroy a lot of land here",—and Mr. Hazen

says the smell, in his experience, would affect the value of land within a considerable radius of the disposal works, and so, as I say, we cannot build a separate disposal work on our own lands, and we are cannot get land on which to build it, and so we said, let us go to the Passaic Valley Sewerage Commission and say "We want
71 to join you, join with you and our other sister municipalities here in trying to develop the resources of this territory and protecting the public health," and I submit to you, gentlemen that in view of the great benefit that is coming from it, in protecting the public health, developing property, improving the condition of such a large proportion of the population of the State and thereby increasing taxes and building up the commerce of the country, and in view of the evidence that navigation is not likely to be interfered with by the improvement, that you will not withhold your approval.

Mr. Lebkuecher: I understand fully that it is not necessary to explain to these gentlemen or this Board that a nuisance exists in the Passaic Valley——

The Chairman: It is within the personal knowledge of most of the members of the Board——

Mr. Lebkuecher: But I would like to have Mr. Eastwood, being the representative of one of the Boards of Trade along the River, tell you his views.

Mr. Eastwood: Mr. Chairman and Members of the Board, I am neither an engineer nor a lawyer, but a plain business man, a resident of the Township of Belleville on the banks of the Passaic River,—born and raised up there. I can remember when the Passaic River was one of the most beautiful streams in this country, perfect in every respect, its waters of the utmost purity, drunk by the citizens of Jersey City and Newark. Some years ago both of those large corporations were compelled to discontinue the use of
72 that water and secure a supply at other points at large expense. Since then, by the increased amount of sewerage deposited in the Passaic River, matters have come to a very terrific condition at the present time.

As a resident along that river, I am here to-day in the interest of this application before your Board. We have got to have relief in the Passaic Valley. We are now losing a certain amount of our population along the banks of this river. Our manufacturing interests are at a standstill, that is, as far as any increase in capital or enlargement of factories is concerned, for the simple reason that you cannot get any large project to locate on the river to-day owing to the condition of the atmosphere during the Summer. As one gentleman has very appropriately stated here, many of the factories have been compelled to close down their operations during the Summer when these extremely disagreeable conditions exist. No man who is in business can fail to appreciate what that means, and also that capital, when it is aware of such conditions, will not invest in or create any enterprises in such a locality.

Now, this matter of the Passaic Valley trunk sewer has been fought out for many years. I believe I am one of the first who adopted or advocated, rather, the trunk sewer. A number of years

have been lost to the people of Passaic Valley by securing proper legislation and by ascertaining the question so as to educate the people up to a point where such a thing is possible.

I must say that I, with great pleasure listened to the gen-
73 tleman who spoke last; it was an eloquent moment to have Paterson come before this Board and advocate the adoption of this trunk sewer and the granting of the application to your Board to deposit this sewage in New York Bay; it is a great pleasure to every gentleman who has been interested in this project since its inception.

Now, in our little town, right above the City of Newark, North of that City, we are in a terrible condition. Not only has property depreciated in value, but it has had a tendency to drive people away from the River, for we cannot keep our property in proper condition. Anyone visiting that town will notice the condition of the houses there; there is not a house there to-day in respectable condition as far as paint is concerned; it makes no difference if you paint the houses three or four times a year, the gases arising from that river take the color out of the paint right away, so that every house there looks as though it had not had a touch of paint for twenty years. I merely state that to show the condition of the atmosphere. That is why we are here to-day, on behalf of the Board of Trade, of the first district of the Passaic Valley Sewerage Commission, asking for this application and for relief, and we think that under the circumstances, that while the City of New York and the City of Brooklyn are placing their sewerage in this Bay, that the State of New Jersey ought to have, if it does not, the same right in this Bay,—it should have an equal privilege,—if they are putting this inculms into the Bay in its raw state, we should have the right here applied for, as if it be not granted it will work the prac-
74 tical destruction of our community.

Mr. Sherrard: Mr. Chairman, and Members of the Board, I only want to speak of this question from the standpoint of the City of Newark; that city, as your Board knows, is already committed to the large scheme of a deep water harbor and dock improvements on Newark Bay, and we know that with the crowded conditions of the New York Harbor will bring this portion of the City of Newark very much to the front, and also all of Newark Bay, and it seems to us as we have looked at this project—I think the Chairman asked us to its location—the location is about four thousand feet to the South of where the tunnel and sewer pumping station is located on this map (indicating).

Now, the proposition of coarse screening and the provision for sedimentation, on this large project, would, in my judgment, relieve the Passaic River and Newark Bay of a good deal of the present deposit which has been a detriment to navigation, and on that one point alone, as has been shown by Mr. Harrison, this continual holding back of the flow of the river causing a deposit in the Bay, is a detriment to navigation, and the pumping out of this portion of the sludge in the sewer will to that extent be an improvement in the

condition of navigation in that vicinity—of Newark and of New York Harbor.

Mr. Lebkuecher: The Mayor of Paterson is here and will hand in a paper, which he would like to form a part of the record of this hearing.

Mr. McBride: Mr. Chairman, and Gentlemen: I do not
75 propose to take up your time, but I would like to present this paper, for your record:

(Mr. McBride here presented the following paper):

"The City of Paterson, in the year 1868, began the construction of sewers discharging into the Passaic River. This action was taken under the authority of an act of the Legislature of the State of New Jersey entitled "An Act to Authorize the Construction of Sewers and Drains in the City of Paterson," approved February 26, 1868.

At that time, the only method of sewage disposal in use in this country was that adopted by this City, namely, the discharge of sewage into running water. Such action was taken in good faith, with the belief that this City had a legal right so to do, and that it was the best and only method whereby the public health and public interests could be subserved.

With the advance of time, of sanitary knowledge, and increase of population, it was found by the City of Paterson in consequence thereof, that such discharge of sewage into a river of the size of the Passaic, was inevitably the cause of a public nuisance. From this nuisance the City of Paterson, through its discharge of such sewage, has itself suffered more than any of its neighbors.

As long ago as the year 1894 the attention of this City was called to the then existing conditions of nuisance, by the local Board
76 of Health. This City was then called upon to defend itself against the charge, that it was the chief cause of the pollution of the Passaic River. This the City denied, and denies now.

In our opinion, the chief sufferer from our own pollution is the City of Paterson itself, and not our neighbors below. We firmly believe that the Passaic River has sufficient volume and diluting capacity to care for the sewage of Paterson alone, without causing any public or sanitary nuisance to those situated below us.

Unfortunately, however, other communities possessing the same rights and privileges granted by the Legislature of the State, as we possessed, have utilized those rights and privileges, as we have, to empty their sewage into the river, until the bulk of sewage has become so great that the ordinary and natural flow of the river is insufficient to properly dilute and take care of such sewage. The result is, therefore, that to-day, and for the last 18 years, a public nuisance, by reason of such discharge of sewage, has existed in the valley of the Passaic River below the Great Falls.

Such nuisance, although in our opinion not affecting the public health, has unquestionably depreciated the value of property contiguous to the river, and has been a decided annoyance to persons living or employed in proximity to its banks.

The initial step taken by those realizing these conditions
77 and suffering from them, was the attempt to pass a general act, in the year 1892, forbidding the discharge of sewage

into any river, stream, lake or pond. This, the City of Paterson, through its official representatives, strongly opposed, and as a means of preventing the passage of such an act, which would be most inimical to the interests of the City, proposed in lieu thereof, that inasmuch as practically all the communities bordering upon the Passaic River were equally guilty, that they should combine and unite their interests, and jointly act in such a way as to remove such nuisance and purify said river. Official representatives of this City, therefore, were responsible for the preparation, the passage and the signing of the bill, passed by the Legislature February 26, 1896, and signed by our respected fellow-townsman, Governor Griggs.

Pursuant to this Act, Governor Griggs appointed, on April 21, 1896, as a commission, our late respected fellow-townsman, Dr. Elias J. Marsh, and Dr. H. C. H. Herold and William T. Hunt, Esq., of Newark; a better selection than which, from any standpoint, could not possibly have been made.

This Commission reported, on February 26, 1897, said report, in brief, being that the interests of the various municipalities bordering on the Passaic River below the Great Falls, were identical, and that it was to the interest of each and every one of these municipalities to unite with the others in a manner, namely, a joint
78 trunk sewer, to dispose of their sewage and prevent the existing nuisance by the discharge of said sewage into tidal waters.

This investigation has been continued up to April 1908. In the work have been engaged the most eminent engineers known to the profession in this country. The mere mention of their names is ample proof of the previous statement, namely:

Col. George E. Waring,
Alphonse Fteley,
Charles E. A. Jacobson,
Rudolph Hering,
James Owen,
Colin R. Wise,
Robert M. Watson,
William Ferguson,
J. J. R. Cross,
William M. Brown,
Gen. Henry M. Roberts, U. S. A.
Lieut. Col. C. W. Raymond, U. S. A.
G. S. Greene, Jr.
E. W. Harrison,
Wm. Barclay Parsons,
Allen N. Spooner,
George W. Fuller,
George A. Johnson,
Samuel M. Gray,
Allen Hazen.

79 The work of two of these gentlemen was done entirely in the interests of the City of Paterson; one, Mr. Gray, being engaged and paid by an organization of the citizens of Paterson,

desiring the good of the City; the other, Mr. Hazen, being engaged and paid by the City officially.

All of these engineers mentioned, who have studied the problem and become acquainted with the conditions and requirements in the Passaic Valley, have agreed——

(1) That a public nuisance existed.

(2) That such nuisance should be abated.

(3) That it was to the interests, economically and from a practical point of view, to each and every municipality bordering upon the Passaic River below the Great Falls, to unite and work jointly to accomplish the abatement of this nuisance.

The question presented to the City of Paterson is purely a business one. The law of March 18, 1907, forbids this City to discharge its sewage, unpurified, into the Passaic River, after December 12, 1912. By an agreement, made through its official representatives, with the Court of Chancery, since confirmed by an opinion of said Court, the City of Paterson has been ordered to cease such pollution on March 26, 1911.

The City is therefore bound in honor, in law, and by the mandates of the Court of Chancery, to cease polluting, by its sewage, the Passaic River, on March 26, 1911.

The proposition, therefore, before the City, was whether
80 this result could best be accomplished by uniting with the other municipalities bordering on the Passaic River below the Great Falls, or by the building of a local sewage disposal system by the City itself.

As has already been stated, the eminent engineers who have given this matter their consideration and study, the universal opinion has been that the most economical and best way to accomplish the desired results was by union or by united efforts. All these engineers, except Mr. Gray and Mr. Hazen, have considered the interests of the District as a whole, and not the special interests of the City of Paterson. Mr. Gray and Mr. Hazen considered the interests of the City of Paterson alone, as distinct from those of the District, and reported on the advisability and the cost of local disposal systems.

Mr. Gray estimated the cost of a local disposal system for Paterson, at $2,670,185, such system being for the disposal of 25 million gallons of sewage daily.

The report of the Passaic Valley Sewerage Commissioners, under date of April 20, 1908, gives a capacity for the carrying away of the sewage of Paterson to the amount of 63,952,300 gallons per day, at an estimated cost to Paterson of $2,008,425.28.

Mr. Hazen (in whom this City has the greatest confidence, both as a man and as an engineer) was employed solely in the interests of this City, and gives an estimate of the cost of a sewage disposal plant at $3,028,190. In his report he advises as follows:
81 "In view of all the facts and circumstances as I have found them, and upon the supposition that a full, just and lawful arrangement with the other municipalities upon the Passaic River is reached, acceptable to the Legislature and to the Governor, I

believe that the interest of Paterson will be best served by joining with other municipalities in the construction of a trunk sewer to take the sewage from the entire district requiring sewage disposal facilities in the Lower Passaic Valley to a point of adequate sea-water dilution in New York or in Newark Bay near the Kill von Kull.

"I believe that this arrangement will be substantially better for Paterson than the separate local purification of her sewage."

Both the scientific and the economic side of this question have been most thoroughly studied, considered and approved by a Committee of the Taxpayers' Association of this City,—an Association without any motive except the preservation and advancement of the interests of the City, composed of citizens whose only incentive is civic pride and whose only object is the interests of the City in which they were born or lived.

Said Committee, after their investigation and study, reported as follows:

"We recommend that Paterson join with the City of Newark and other municipalities in an effort to secure the disposal of sewage by discharging it into the sea without treatment, other than screening."

The Special Committee appointed by me, the function of
82 which was to advise the officials of Paterson upon the subject of the most economical, the most scientific and the best method for the disposition of the sewage of Paterson, after a most thorough and exhaustive study of the work already done, and after personal investigation of the subject sufficient to satisfy themselves of the justice and right of their conclusions, reported in part as follows:

"That we have fully investigated the subject of sewage disposal and are unable to find any system of local disposal that would be applicable to the City of Paterson, and that, owing to the date set by the Court of Chancery, namely, March 26th, 1911, limiting the time of our use of the river as a sewer, it is necessary that we take some action without further delay.

"Therefore we are of the opinion, that in order to comply with the order of the Court of Chancery and of the General Sewerage Act of 1907, pertaining to the discharge of the sewage of the Passaic Valley Sewerage District, limiting our period for the discharge of sewage into the river, that this City should enter into a contract with the other municipalities of the Passaic Valley Sewerage District, and with the Passaic Valley Sewerage Commissioners, with the understanding that the City may withdraw if the cost of the proposed trunk sewer exceeds the present estimate of $12,200,000.00, paying our share for the securing of working plans, estimates and bids.

"We therefore recommend, that the Mayor and Board of
83 Finance be authorized to sign such contract as proposed by the Passaic Valley Sewerage Commission, and that this City pay its share for the preparation of working plans and estimates

and the securing of bids, leaving, however, the ultimate question of the joining in the trunk sewer plan to future developments."

The Board of Finance, acting upon the above recommendation, resolved unanimously to enter into a contract with the Passaic Valley Sewerage Commission and the other municipalities interested, for joint action in the disposition of their sewage.

The City of Paterson is therefore of the opinion that its best interests can only be subserved by union with the other municipalities of the Passaic Valley and the joint discharge of their sewage into tidal waters.

At the present time, the sewage of Paterson is discharged above the Dundee Dam and above the tidal waters of the Passaic River. This sewage is carried down and is now discharged through the Lower Passaic River, Newark Bay and the Kill von Kull, into New York Bay.

The joint action of the various municipalities contemplated does not increase this discharge of sewage but simply provides for the collection of such sewage as will, under existing conditions, inevitably be so discharged, and its discharge at another point in New York Bay.

The interests of our City demand, in our opinion, a joint system of sewage disposal for the Passaic Valley."

Mr. Lebkuecher: Now, gentlemen, I do not think it is necessary for us to call any more, perhaps, of the people who are here at your invitation——

84 Col. Knight: There is one thing,—these gentlemen who have been called might be requested to remain until opportunity has been given for such questions as the opposition may wish to ask.

Mr. Lebkuecher: I will arrange for that,—I have already asked them to remain.

Mr. Heck, of the Jersey City Board of Trade, would like to address the Board in behalf of the application.

Mr. Heck: I only wish to say that, on behalf of the Board of Trade of Jersey City, and not only do I appear as a member of that Board, but as one of its Board of Directors, a few, a dozen or more, of whom are here,—that that Board has carefully considered the plans of the Passaic Valley Sewerage Commission and are in hearty accord with all that the Commission has determined and are supporting it fully; that we know the present conditions, that has all been said and that is about all to be said; we could only reiterate what has already been said. We think it is an improvement, that would affect Jersey City materially, as well as Newark Bay. A good portion of our City is bounded by Newark Bay,—the upper portion, by the Newark Bay and the Hackensack; it would also be an improvement to Jersey City flats and Bayonne Neck, and we think this matter of sedimentation and sewage in the Passaic Valley and Newark Bay ought to be done and as speedily as possible.

I am the representative, also, of owners of land in the lower portion of Jersey City, in the neighborhood of this project and now in

the way, will have to be applied to personally for privileges,
85 and I can say, personally, as representing eighteen or twenty acres, that we will in no way interfere with the project but hail it, and we thoroughly advocate the adoption, or, at least, the consent of your Board to the privileges now sought for.

Mr. Payne: I am here, representing the Riparian Commission of the State of New Jersey, simply in answer to the invitation of this Board, and I have nothing to say in addition to what has been so ably said.

The Riparian Commission is intrusted with the improvement and sale of its riparian lands, and anything that would enhance or raise their value is, of course, in line with their duties, and they feel sure that the Commission in the direction of this important work, are attending to it properly, and I have nothing further to add.

Mr. Lebkuecher: I do not think it is necessary to call any more advocates after the presentation that has already been made; there is only one thing I would like to add, and that is,—when this project of discharging the Passaic Valley sewage into New York Bay was first brought forward by the engineers employed by the Passaic Valley Commissioners, we, as commissioners were uncertain as to whether that was the proper thing to do, and we were told by the engineers and assured that it would cause no pollution whatever.

The question also came up, advanced by other people in the State, and the Legislature passed an Act that we should first find out, and get the best information possible as to whether there would
96 be any injury in New York Bay, by reason of this discharge, if discharged as proposed, after screening and sedimentation.

In pursuance of that Resolution of the Legislature, the Commissioners got the opinion of a number of experts from the Army Board, and we have here ((handing the Chairman a paper) our report, giving the opinion of General Henry M. Robert, Lieut. Col. C. W. Raymond, and C. S. Greene Jr., Civil Engineer, and I would like to submit it as accompanying our application.

If there are any questions to be asked, these gentlemen are ready to be interrogated.

Mr. Dean: The State Commissioner of Health, Dr. Porter is here, and says he will have to catch a train back to Albany—

The Chairman: Dr. Soper was going to address the Board—

Dr. Soper: Mr. Chairman, if you will hear those who are down on the programme when their names are called, they can make their remarks—the questions might come afterwards—otherwise a number of people here I know want to go out of town and it is impossible for them to come back, and they will not have an opportunity to be heard.

Mr. Dean: It is absolutely necessary for me to ask certain questions, to cross-examine, some of these witnesses for the reason that they have not given certain details it is necessary to have in order to understand the nature of their application entirely—

87 Mr. Riker: I do not think there should be a cross-examination of our witnesses; there is a litigation pending between the State of New York and the State of New Jersey, before the Su-

preme Court of the United States, and I understand that the gentleman who is on his feet represents the State of New York, and I do not think that the witnesses on behalf of the State of New Jersey, if he so terms them, should be subjected to a cross-examination, and I think nothing should be asked of those witnesses except what is actually germane to the subject-matter before this Commission. I do not think there should be a fishing excursion for evidence against the State of New Jersey.

Mr. Dean: Mr. Chairman, I am not on a fishing expedition; I want to find out what is going to become of this sewage. I wish to find out what the specifications of this Commission consist of? As the representative of the State of New York I believe we have the right to find out whether this sewage is going to interfere with the navigation of this harbor. It is true that the United States Government has the primary right over the navigable waters of this State, but the law is well-settled that the State of New York, or any State in which are navigable waters, has a secondary right, and that is what we wish to invoke, and it is for that purpose that I want to bring definitely to a head just what this screening chamber, this gravity chamber is to consist of,—what is the size of the dispersion area, and the size of the solid matter in suspension, and how
88 it will affect navigation with reference to the largest of the big ships which enter this harbor, representing investments of millions of dollars, and, consequently, the commerce of this State and City.

The Chairman: You only want the engineers?

Mr. Dean: Yes, sir.

Dr. Soper: Every one of these men (referring to names on list) may go out before Mr. Dean, or one of your Board has put questions to the engineers with regard to this matter.

Mr. Miller: I have no especial status here, except as I represent the Department of Justice, and I did not wish to interrupt the presentation of the case by the proponents, in order to ask certain questions as to the bearing of the application with reference to that Department, and I am perfectly willing to wait and suit the convenience of this Board. I want to know, on behalf of the Department of Justice what effect this will have upon commerce and navigation, and, of course, that can be brought out by other methods. I do not want to ask any questions, and I therefore hope that the gentleman representing the State of New York will bring out such information as desired, of course, subject to the right of New Jersey to answer or not.

The Chairman: Mr. Miller, this Board has been deputed to hold this hearing, and they are men who have had experience in this sort of work for a good many years. I think the mind of the Board is pretty well made up as to what information they want. We want the information covered by the endorsement of the Chief of
89 Engineers in sending this matter to us. I do not like the idea of bringing in technical matters, if it can be avoided——

What is the sense of the Board? Shall we give Mr. Dean an opportunity to proceed to cross question the witnesses——

Col. Knight: I do not like the word cross question or cross-examine; I should prefer the word "question."

(The sense of the Board—after a moment's discussion.)

The Chairman: You may proceed, Mr. Dean, to question the speakers who have made their presentation.

Mr. Dean: I would really prefer to let the other speakers get through, and then ask such questions as I may——

The Chairman: Then that may be done.

Dr. Soper: Mr. Harrison has made the chief remarks of a technical nature, and described what was intended by the Passaic Valley Sewerage Commissioners.

I will not attempt to reply to many of the statements which he made, although I am very strongly tempted to do so. I am sure that some of the fallacies which have been fallen into and stated by Mr. Harrison, will appeal to others who will speak here before your Board——

Col. Knight: But, Dr. Soper, please do not give us anything by indirection: If you have anything to criticize or to comment upon in a person's statement, if he has made, in your opinion, an error, please refer to that error directly.

90 Dr. Soper: I would call attention, as one error, to the fact that the disposition of sewage in the New York Bay, and its effect, has been largely based upon the observed effects of the disposal of sewage into fresh water, and to state that the effects, particularly with regard to sedimentation of solid matters in salt water and in fresh water, are quite different.

I have an exhibit here to offer in that connection. Sewage sludge has been mixed with fresh water in one bottle and an equal quantity of sewage sludge with salt water in another; the bottles have been allowed to stand, in this case, one hour; the clearer bottle shows the effect in salt water, where the sewage sludge is deposited much more rapidly than in fresh (Referring to photograph of exhibits mentioned). In this case (referring to separate photograph) the exhibit shows the effect of three hours' standing.

Col. Knight: Have you any volumetric determination as to the amount of dispersion?

Dr. Soper: None has been reached.

Col. Knight: This is merely a question of experience?

Dr. Soper: A question of experience.

Attention is called also to the fact that the specific arrangement for screening and settling and discharging the sewage are not given in the report, and have not been given by any of the gentlemen who have spoken here this morning.

You are requested to form an opinion on the statement that the necessary works will be constructed. The Metropolitan
91 Sewerage Commission has requested of the Passaic Valley Commissioners information on this point and has been no more able to get it than your Board has this morning.

The rest of my remarks, for the sake of accuracy, and to economize time, will be read; and are:

"The Metropolitan Sewerage Commission is an official body

created by the State of New York to investigate and report on means for permanently protecting and improving the sanitary condition of the waters of New York harbor and vicinity. Its report is to be made by May, 1910 (Do you hear me, Mr. Harrison)?

The present hearing is not a suitable occasion for extended discussion of the sanitary aspects of the Passaic Valley sewer, but this commission desires to make a few remarks upon the possible injuries which may result to navigation if the Passaic Valley project is carried out.

Although possessing certain novel features, the Passaic Valley project is not altogether new. Nearly thirteen years ago legislation was secured in New Jersey looking to a general system of sewerage for the sanitary improvement of the Passaic Valley, and this project has been urged in some form ever since. For the last seven years, at least, it has been proposed to collect all the sewage of the Passaic Valley district and discharge it without purification into New York harbor. The question whether injury would be done to the harbor if the Passaic Valley sewer was allowed to discharge crude sewage into these waters has been the subject of several investiga-
92 tions. In 1903 the Passaic Valley Commission was required by the New Jersey legislature to investigate whether the proposed outfall was likely to cause a nuisance to persons or property within the State of New York. On that occasion favorable reports were secured from a number of prominent engineers and, with the advice of the Attorney General and Governor of New Jersey the project was allowed to proceed.

Earlier than this the Harbor Line Board made an inquiry as to whether the discharge of the sewage would injure navigation. At that time it was proposed to discharge the sewage of the Passaic Valley into Newark Bay at a point about twenty-two hundred feet above the bridge of the Central Railroad of New Jersey. The Board examined this project and made an adverse report upon it under date of May 28, 1897. The Board summarized its opinion in the following words: "It is easy to see that it will require only a few years to make the proposed sewer system not only a public nuisance but a serious obstruction to the navigable waters adjacent to the harbor of New York."

In 1903 the Legislature of the State of New York created the New Yark Bay Pollution Commission to investigate the threatened pollution of the waters of New York Bay and vicinity. One of the recommendations of the Pollution Commission is especially worthy of attention at this hearing. The Pollution Commission protested against the execution of the plan to discharge the crude sewage of the Passaic Valley into New York bay and advised the Governor of New York that in the event of the Passaic Valley Commissioners
93 pressing the construction of their works, action be brought in the Supreme Court of the United States against the State of New Jersey and the Passaic Valley District Sewerage Commissioners.

So far as the proposed plan for diffusing the Passaic Valley sewage through the tidal waters can be comprehended, it gives inadequate assurance that the sewage will be immediately diffused and

dispersed. Diffusion and dispersion are phenomena which, as related to the discharge of sewage into harbor waters, are not sufficiently understood to be within the range of exact engineering control. Experience shows that the discharge of large volumes of sewage into a natural body of water generally produces evil consequences in the vicinity and that the extent of these evils increases more rapidly than the quantity of sewage.

The Passaic Valley scheme bears a certain resemblance to works which carry the sewage of Boston and its neighboring municipalities into Boston harbor, and it is understood that the experience of Boston has guided the Passaic Valley Commissioners in making their plans. Having visited Boston and seen the outfalls in that vicinity the Metropolitan Sewerage Commission has no hesitancy in expressing the opinion that the conditions in Boston harbor should not be duplicated in New York bay.

Freedom from evil effects cannot be urged on the ground that grit and large solid particles will be removed before the sewage is discharged. The amount of harm which might result would not be confined to the channels near the sewer outfall. In places
94 remote from the mouths of sewers the bottom of New York harbor is already covered with accumulations of fine black material which it has been impossible to distinguish from sewage sludge. The United States Government has removed thousands of cubic yards of this material from Ambrose Channel.

The evil results which would follow the deposit of sewage matters in the channels would not be restricted to the mere cost of dredging. The interference which vessels might experience from the presence of dredging machines should also be considered. In this connection it should be remembered that the proposed outfall works would be located in the land-locked part of the harbor on the edge of the main ship channel, and consequently in the direct path of vessels bound in and out of New York, Newark Bay, the Kill van Kull and close to the path of the Municipal ferry between Manhattan and Staten Islands.

The need of affording adequate sewerage facilities for the rapidly growing municipalities in the vicinity of New York City, and the importance of keeping the river tributaries clean are fully recognized by the Metropolitan Sewerage Commission. But the practice of sanitating inland municipalities at the expense of the harbor is unwise. There is a limit to the quantity of filth which these waters will tolerate and which the public will consent to have floating about. Investigation has shown that portions of the harbor already receive sewage in excess of their capacity to assimilate in a harmless and inoffensive manner. It is the opinion of the Metropolitan
95 Sewerage Commission that the discharge of sewage into these waters should be restricted to such municipalities and districts adjacent to the bay as cannot otherwise dispose of their sewage except at prohibitive cost.

The present project of the Passaic Valley Commissioners is not the only practicable way of handling the sewage of the Passaic Val-

ley. It is feasible to purify the sewage of the twenty or more municipalities concerned by public works constructed for that purpose. The cost of constructing and operating works to purify the sewage of the whole Passaic Valley would not be materially greater than the cost of constructing and operating the works under the plans proposed, with their grit chambers, screens, pumping station and large tunnel under Newark Bay, the Bayonne Peninsula and New York bay. If such purifying works were built a harmless and inoffensive effluent could be discharged into Newark bay in place of discharging the raw sewage as now proposed in a more or less putrefying condition into New York bay.

It is the opinion of the Metropolitan Sewerage Commission that the discharge of sewage in the manner and in the quantities proposed by the Passaic Valley Sewerage Commissioners would be detrimental to the interests of navigation and that this project should be opposed by all who desire to see New York harbor maintained in a clean and unobstructed condition.

Mr. Dean: Dr. Porter, the State Commissioner of Health——

Col. Knight: Before Dr. Porter speaks,—Mr. Soper, you
96 spoke of some parts of New York bay being already polluted to the limit—have you those in mind?

Dr. Soper: I am speaking of Gowanus Canal and Newtown Creek.

Col. Knight: You would not consider those as exemplifying the general condition of affairs around New York Harbor?

Dr. Soper: The general condition, no.

Col. Knight: A special case?

Dr. Soper: Yes.

Col. Knight: And, in the case of Gowanus, do you notice any perceptible difference in the condition there as you go from the head of the Canal down to the mouth of it?

Dr. Soper: There is no very material difference until you get to the Bay.

Col. Knight: But you will admit that at the Bay the relative percentage of trouble—if I may so call it—is very materially reduced?

Dr. Soper: It is reduced, but it is difficult to say whether materially or not.

Col. Knight: But you are able to determine that?

Dr. Soper: Contrary to what has been said this morning, there are no standard sewerages.

Col. Knight: Then how are you going to pass on the question of pollution, if you have no standards?

Dr. Soper: To fix the sanitary standards of the harbor
97 for all time, is too much to do, or what the tide will do or the water permit; it is not necessary to-day to call people outright falsifiers——

Col. Knight: We are not talking about calling people names. When you say there are no standards,—what do you propose, yourself, your Board, to be governed by; where does the limit of pollution rest? You say it has been reached in certain localities in New York Harbor, and then you say there is no standard?

Dr. Soper: To answer you directly, we will include the Passaic River as one case in which the sense of the public of its odor has established a standard.

Col. Knight: Then your standard is that of the nose?

Dr. Soper: Of the nose, and of the eyes, and of the public health and of other considerations——

Col. Knight: But nothing definite?

Dr. Soper: This Metropolitan Sewerage Commission that exists to-day and which I represent as one of its members, has for one of its undertakings to come as near establishing a standard—a sanitary standard for New York bay as is practical——

Col. Knight: But you do not admit that anything exists to-day as a standard?

Dr. Soper: Not that can be stated in mathematical terms; no.

Col. Knight: Well, that can be used, practically, for de-
98 termining whether the discharge of this sewage will pollute the waters of New York Bay?

Dr. Soper: We believe that the condition of the waters in Boston Harbor could be instanced as a good criterion.

Col. Knight: How are you going to apply the conditions of Boston harbor, practically, to New York harbor?

Dr. Soper: Boston harbor—there is a project proposed here which seems likely to produce the same conditions as in Boston, or worse, and we object to those conditions; we think that that is a practical application.

Col. Knight: You think that by developing or appropriating the Boston methods, either or both, is going in the wrong direction?

Dr. Soper: We do.

Col. Knight: But you have no standard or standards to measure by, as to whether that is wrong or right?

Dr. Soper: Not as yet.

Dr. Porter: My main object in appearing before you this afternoon is to state to you what the policy of New York, so far as the State Department of Health is concerned, is, regarding the pollution of the streams and of the waters of our State.

I believe that the discharge of raw sewage into the waters of this, or any other, State indicates a defective civilization.

I believe that the progress of science has been such and the
99 progress of our health experience has been such that we are no longer justified in polluting deliberately and with full knowledge of the consequences that may result, the waters of New York harbor or of any other harbor or of any other waters, where it is possible to purify this sewage before it is introduced into those waters, and I withhold permission whenever it is asked of the Department, and have taken steps to prevent or remove such conditions.

(Reading:) "In appearing here to-day in opposition to this Passaic Valley project, I wish to be clearly understood as in no way intending to oppose, nor obstruct, any great and needed sanitary measure. On the contrary, I am here to oppose only the execution of a project that may not carry with it the fullest assurance that the

benefits to be secured will be realized in a manner that will not give rise to objectionable conditions—whether from objectionable deposits, offensive odors and appearance, or injury to health.

In approaching then the question at issue—the pollution of the tidal waters of New York bay—I believe that it will be both wise and profitable to consider the question from the most general and comprehensive viewpoint; to consider the Metropolitan District as a whole, including the municipalities of both States; to weigh the question involved with respect to the needs of the entire district, before stating any conclusions or giving a decision in any particular case. The need of this comprehensive viewpoint and reservation of decision seems to be particularly emphasized at this time in view of the fact that we are now beginning to realize with greater force the extent and effect of present pollution upon the waters of the
100 harbor. Furthermore, the study of this whole question, as you know, has been entrusted by the State of New York to an Investigating Board, which has been studying this problem for some time and which it is expected will, within a reasonably short time, report the necessary information that will enable not only your Board, but others entrusted with corresponding duties, to consider intelligently and act safely in regard to it.

To give a decision in advance of such knowledge would, in my opinion, certainly be a step in the wrong direction.

The importance of any evil consequences that might arise from the proposed discharge of sewage from the Passaic Valley District into New York Bay can hardly be over-estimated. They would affect not alone the people of New York City but the cities and communities along the New Jersey shore as well. They would involve not only the comfort, health and life of these communities, but would also affect vast industries such as commerce, shell fisheries and others. It is, in fact, because the questions involve the health, comfort and welfare of the citizens of this State that the State Department of Health is particularly interested, and wishes to appear here to appeal to you for cooperation in conserving its policy in preventing a further pollution of the waters of the State.

The policy of the Department during the present administration has, I believe, been so fully and repeatedly expressed that it is by this time fairly well understood throughout the State. Briefly
101 expressed, this policy is in opposition to the further pollution of the waters of the State, whether inland or tidal, in all cases where such pollution may appreciably affect the purity of these waters. In accordance with it, the State Department of Health has during the past four years used every effort to remove existing pollution and restrict the discharge of additional sewage into our streams and tidal waters.

Owing to territorial jurisdiction in this matter, the plans for this project have not so far come before me, either officially or informally, and I am, therefore, not in a position to speak with any degree of authority as to the proposition as a whole or in detail. I am informed, however, that the plan of the Passaic Valley Sewerage Commission is to collect the sewage of about one and a half millions

inhabitants of New Jersey municipalities lying along the Passaic River in a large trunk sewer some twenty-six miles long, and to discharge it into Lower New York Bay in the vicinity of Robbins' Reef Light. As to what methods will be used to purify this vast amount of sewage, or as to the conditions under which it will be discharged at the outlet, or as to the effect of the discharge of this large volume of sewage, at the proposed single outlet, upon the waters of the harbor and the health and comfort of the people, are questions which are of vital importance, but about which the people of New York have not as yet received positive information or assurance.

Judging from the report of the advisory engineers, how-102 ever, it would appear that they recommend, and we are accordingly led to believe that it is the intention of the New Jersey authorities to provide, only a partial purification of this large volume of sewage. According to these engineers, it is proposed to construct upon the Newark Meadows a grit or sedimentation chamber and provide mechanical screens for removal of the coarser or grosser solids, and to provide at the outlet near Robbins Reef some six miles from shore, and at edge of the main channel, a system of multiple outlets submerged some forty feet below the surface, distributed over what they term a dispersion area.

There would seem to be little doubt that this method of disposal, compared with the present method in vogue in New York, where sewage is discharged without settlement or screening at pier and bulkhead lines, near the surface of the water, is relatively superior, judged from the standpoint of methods. As to the absolute efficiency of the method, under the conditions which it is proposed to discharge this sewage, it is not so clear. One thing we are certain about, and that is the inadequacy of the present method of disposal in New York City, which is apparent to any careful observer who inspects the condition of sewage pollution along the shores of Manhattan, and for a considerable distance above and below the city. It is true that the proposed volume of sewage from the Passaic Valley trunk sewer may be small compared with present or future volume of sewage from Greater New York—perhaps only ten per cent.—but have we sufficient knowledge at this time to be assured that this volume of sewage discharged with only clarification 103 within the limited dispersion area proposed will not become in any way objectionable?

Viewing this question broadly, and in the light of what we do know as to efficient methods of sewage disposal, we can state with little doubt that there are methods of disposal by purification which are not only more efficient, but probably no more costly, than the method of disposal such as that proposed for the Passaic Valley District. The experience and successful practice in both this country and abroad fully bear out this statement. And, if this be so, it would seem that such methods of purification might better have been adopted, or at least proposed, as an alternative proposition.

I believe, therefore, that in view of what I have said, that it is your duty, and I would urge it upon you, that you give the most careful consideration to this project, and judge it not only in the light of the more restricted question of the silting up of the harbor

but also in the light of the sanitary questions involved. I trust that in doing this you will bear in mind the policy of the State Department of Health in reference to the protection of the waters of the State from pollution, and the fact that in matters pertaining to stream pollution the trend of public opinion and views of sanitarians is towards higher standards of purity. Finally, I would urge in this matter, that you withhold your approval of this project until such full information is furnished by the New Jersey authorities as to the methods of purification they propose to adopt; and that
104 you withhold your approval unless you are assured that these methods will safely dispose of this sewage without danger of offense, or injury to health, or damage to the many and important interests which are at stake."

Col. Knight: Have you not any definite information to give about those more efficient methods? What would you advise?

Dr. Porter: The methods employed, for example, at Saratoga, New York, by sedimentation, by septic tanks, by rapid contact beds made of coke, in fact, a dozen methods.

Col. Knight: You certainly give credit to Mr. Hering of being familiar with those methods?

Dr. Porter: No doubt at all.

Col. Knight: Generally, you do not consider his recommendations as made seem in accordance with the results obtainable by those methods?

Dr. Porter: No, sir.

Col. Knight: You claim that those are more efficient than are the methods he recommends?

Dr. Porter: I do not know that he has recommended any method for purifying the sewage,—as I understand it, he does not believe that the purification of the sewage is necessary——

Col. Knight: You would say that he recommends clarifying rather than purifying?

Dr. Porter: Yes, sir; he recommends clarifying, rather than purifying.

Dr. Darlington: Colonel Lockwood, and Gentlemen of the
105 Commission: One of the gentlemen who spoke in favor of the application, brought up a certain legal question; I did not know whether that would be brought up this morning or not, and all that I wish to say are two or three words. I presume that you are all familiar with the legal aspect of the jurisdiction over the waters of New York harbor, but at the same time I desire to call your attention to the fact that the laws have set down that the State of New York shall have and enjoy exclusive jurisdiction, as to quarantine, over all of the waters of the Bay of New York and Hudson river, and, still further, that the State of New York has also jurisdiction over the wharves and docks and shores and land and over the vessels and crews, and that vessels shall be stopped and quarantined, and laws in relation to passengers, and so on,—in other words, the law gives jurisdiction beyond the State of New York; that the State of New York and the City of New York has jurisdiction over the health of the harbor, and I recently received a decision

from the Treasury Department on that question relative to something along that line——

Mr. Riker: May I be allowed to interrupt for a moment? Does the Board propose to hear argument? We did not understand that this Board would hear legal argument——

The Chairman: We will leave that out——

Dr. Darlington: We will leave that out, but, let me say that, on account of having jurisdiction, the Department of Health of the City of New York would certainly exercise the jurisdiction
106 of the City of New York should they attempt to commence to build; it is not a case of waiting, as one gentlemen spoke of as being the practice in equity, until we could prove the existence of a nuisance——

Col. Knight: I do not understand that any permit from the War Department would prevent you from commencing to act——

Dr. Darlington: If I understand correctly, the Harbor Line Board was not created to give permission for encroachments upon the harbor, but to prevent encroachment——

The Chairman: The question of jurisdiction is not now before us; we would not pass upon the question of jurisdiction; this hearing is to ascertain and report concerning the matters set forth in the statement of the Chief of Engineers on the application——

Dr. Darlington: I simply wish to state, then, in regard to some of the arguments that have been raised,—I would like to say that this supervision, which is vested in the City of New York, over the outlets of the harbor, would be exercised.

I would like to ask this question, which they might answer at some future time; as to who is to supervise this sedimentation and screening? Will they permit officials of the State of New York to supervise those operations? Can the officers of the City of New York see that it is properly done?

The Chairman: That is a fair question for you to settle with them.

Dr. Darlington: And, also, if it be true that the paint comes
107 off the houses along the line of the Passaic River, what are we to assume but that after it reaches the Bay it will do the same to the vessels——

Col. Knight: It certainly will, if it is in the same condition——

Dr. Darlington: It is not claimed that they intend to purify it, but still, as the arguments seem to be very thick, by the engineers, who have not been able to say or determine definitely anything about it,—as this seems to be largely an experiment, why do not they let the first sewer of this kind, as proposed by the State of New Jersey run down and empty opposite Long Branch, Asbury Park, or some of the other New Jersey resorts, and see whether, in front of their own lands, it does any damage or harm?

As a general proposition, sewage is unsanitary, and the pollution of water by sewage is unsanitary, and if it is intended to increase the pollution of the water in New York Harbor by means of this new sewage system from New Jersey towns, a heavy burden of proof rests upon the persons who propose this increase of pollution, to show that it will do no harm.

I desire to submit that the burden of proof does not rest upon the City of New York, but upon the State of New Jersey, and that if there is any question of doubt in the minds of this Board, any doubt whatsoever, they are not at liberty to simply pass judgment upon it, but that they must decide upon the side of safety. This is a general principle in all public health work.

108 The time has passed when it is necessary to show that a condition produces pestilence in order to be a nuisance and require correction. The standards of hygiene and of public decency are continually becoming higher. What was permitted twenty years ago is not to be tolerated to-day, and what is tolerated to-day will, in all probability, not be permissible twenty years hence. The fact, therefore, even of noxious and disagreeable odors must be taken into consideration, under the laws of the State of New York. Nay, more, there is large flotsam in the water, and even to-day driftwood which is polluted by excrementatious material is being carried into the houses of tenements,—people pick up this fire-wood, covered with excrementatious matter and take it home. We believe we have traced many cases of typhoid fever to the condition of the flotsam in New York bay.

The Metropolitan Sewage Commission was created to formulate a policy of sewage disposal for the whole metropolitan district, and, in due course, that will be done. How can we ever create better conditions if we allow these things to come in here now, as proposed by this application? The Metropolitan Sewerage Commission has already registered its opinion against the Passaic Valley project, and has enunciated the principle that large volumes of raw sewage from municipalities not on the shores of the harbor should not be discharged into these waters. It has come to my knowledge that the Commission has knowledge of many facts bearing directly upon

109 the sanitary side of the question which at present they evidently do not feel at liberty to put forward: Therefore, I think it will be better to let this application wait until some of those questions are settled.

Not only must we think of the condition when these great works are first put into operation with six hundred thousand people contributing sewage, but what will occur, let us say, in 1940, (and we must also take into consideration the suspended material which comes from streets and roads of that kind, which, on account of the streets not being paved in those country districts, come under the New York City standard) and subsequently, when the waste of one million, six hundred thousand people would probably be flowing out at that point.

The persistence with which these people, who are interested, endeavor to carry out their project, means that the people of the State of New Jersey do not care whether the harbor of New York be clean or otherwise.

The one reason above all others, it seems to me, why New York to-day is a great commercial center, is because of its efficient quarantine. If it were not for that, we would not have the commerce we enjoy. Let any great plague or pestilential disease become epidemic

in the City of New York through laxity of its health officials or the quarantine and I ask you, what would become of the commerce here? Why is it that New Orleans, with its splendid geographical position at the mouth of a great river, over which freight may be carried at a minimum expense, is not the greatest commercial center? Simply because of its history in the past with its relation to yellow fever. That is why I am here to-day. We are very jealous of health and quarantine regulations as it affects our commerce, and unless it can be proven absolutely that no nuisance whatever will be created in any way, shape or manner, the burden of proof resting upon the people who endeavor to build this work, we do not believe that they should be at liberty to undertake the work, and that you gentlemen, and all others in authority, should take the safe position, and prevent it.

Col. Knight: When that sewer was proposed to be built above Newark, at Passaic, the court did not take that position?

Dr. Darlington: I do not know with regard to that case.

Col. Knight: There the court said that they could not bring a suit to prevent the nuisance, but you must prove the existence of a nuisance, which you are going to prevent.

Dr. Darlington: We prevent nuisances before they are created in this City; we prove that the conditions would create the nuisance, and prevent its creation.

Col. Roessler: You represent the Health Department of the City of New York?

Dr. Darlington: I do.

Col. Roessler: The gentleman who preceded you referred to a State law which aimed to prevent the pollution of all streams navigable and non-navigable; that applies, of course, to New York Harbor?

Dr. Darlington: Yes, sir.

Col. Roessler: It applies to Newtown Creek, that we all know to be polluted?

Dr. Darlington: Yes.

Col. Roessler: Has anything been done to abate the nuisance there, under that law?

Dr. Darlington: Yes; things have been investigated looking towards the abatement of conditions there, by the Department of Health of New York City; we will not permit slaughter houses to dump blood or refuse; we make them keep out. We are endeavoring to correct that condition, but we are waiting until we can have the report of the Metropolitan Sewerage Commission, which is to be rendered in 1910. We have corrected many of the evils, but we cannot correct them unless we can stop sewers of this kind from being allowed to enter the harbor. Daily we find cases where we can trace typhoid fever—as near as you can trace anything of that kind, to people bathing in the waters of the Bay, and we will not permit the baths to be located off pierhead sewers to-day,—the Department of Health stops those permits.

Col. Roessler: And has any plan been formulated, tentatively even, that will prevent those obnoxious sewers entering those streams

along North Bay? Has anything been done looking to having that effluent cared for or purified in some way before it enters into the harbor of New York?

Dr. Darlington: Not as yet.

Col. Roessler: Is it contemplated?

112 Dr. Darlington: Yes; it is contemplated.

Col. Roessler: Will you please state what is contemplated?

Dr. Darlington: That belongs to the Metropolitan Sewerage Commission.

Mr. Dean: I am familiar with the law on the subject and I will take it up later on.

Dr. Darlington: It is contemplated; I do not know what methods will be employed.

Col. Roessler: I do not know that that has any special bearing on the question before us, but inasmuch as the matter has come up I thought it seemed just as well to inquire concerning it.

Dr. Darlington: There is one other point raised by the applicants, that I wish to speak of. It was spoken of, about the City of Hamburg having cholera within it, and Altona although using the same water—of the river Elbe—into which the sewage of Hamburg was discharged, not having the cholera within its borders except cases where water had been drunk in Hamburg. Now the reason why cholera was in Hamburg was simply because it drank its own pollution; the reason why Altona did not have it was because their drinking water was filtered. Filtration takes out the bacteria. On the question of bacteria, we have been able to trace that water acts—operates chemically on suspended matter or bacteria in coming over a long distance, to a certain extent, and bacteria are by this action to an extent eliminated.—it takes a long distance. Now, the

113 Croton water shed is comparatively free from nuisances, the lakes and streams or most of them have been acquired, and the edges of the streams have been acquired, and sewers diverted, and everything, yet in the City of New York I can find the colon bacillus, right in the waters which have been thus safeguarded, in the City of New York.

Col. Knight: We are not proposing to use the waters of the Hudson river for drinking purposes; that is used for cleansing the streets and for fire purposes.

Dr. Darlington: But people put their hands into it, they wash their hands in it, and bathe in it; and it mingles with the dust in the streets, and we have, we believe traced cases of typhoid fever to this very source of flushing the streets with that water, and we think the streets and the City would be better off without it.

(The hour of 1.35 p. m. having arrived, the Chairman announced a recess until 2 p. m.)

(After recess—2.10 p. m.)

The Chairman: The gentlemen will come to order, please.

I want to say that it is the sense of the Board that it is not proper or necessary to hear anything in regard to the law features of this

situation, for the reason that the Secretary of War, if he should grant a permit, merely withdraws the objections of the War Department, but confers no legal rights: What we do want to hear is with regard to the matters affecting the question of navigation.

Mr. Higgins: Mr. Chairman and Gentlemen of the Board,
114 I come here representing the Chamber of Commerce of the City of New York who, I think I can make the assertion without fear of contradiction, are a disinterested body of men in the City of New York—the most disinterested body of men in the City of New York, and I want to make this emphatic because I come here with the most intense spirit on the part of the Chamber, in opposition to this movement, and, therefore, I make the assertion in the first person and say to you that they feel it is necessary to raise these questions upon this application; and those gentlemen have no motive of their own to consider; they are trying to do exact justice to the world, and their sympathies are with you in every way; there is nothing you undergo or suffer in your community over there that is not regretted, but what we sympathize with you.

Now, gentlemen, there are certain important facts I must remind you of. The City of New York cannot preserve her commerce unless she preserves absolutely her condition of a perfectly safe port, a safe port for vessels to visit and for passengers to land to carry on their transactions in the City of New York. Now, it must be remembered that the commerce of the City of New York represents almost the great bulk of the foreign commerce of the United States, and you can see how very important a matter it is to all the citizens, not only to the citizens of the City of New York, but to the whole citizenship of the United States.

I represent both the Committee on Harbor, and the Com-
115 mittee on Foreign Commerce. I am the Chairman of the Commitee on Harbor and Shipping, and Mr. Shweppe, who is chairman of the Committee on Foreign Commerce, requested me to make my appearance in his behalf.

Now, there are certain features about the harbor of New York that I am very certain very few people know. I am one that does know. I am the President of the Board of Pilots, and from that Board I learn facts, and they have assured me that there is a strange natural phenomenon in this harbor; that there is a body of water, between about Yonkers and just southerly of Robbins Reef which simply oscillates backwards and forwards and never reaches the ocean. Now, that is a very strange fact, and they have studied it mathematically. One of them told me only yesterday that he had stood on the shore near Governors Island and had noticed a barrel go backwards and forwards in this current, down to near Sandy Hook and back, it returned eight times without losing sight of it—eight times—that shows the return of the barrel in the tide; it was a proof to him of the fact he had stated to me, which was that this body of water oscillates back and forth and never reaches the ocean, and it is therefore the source of the deposit in the harbor, whot is true of the barrel is true in respect to anything the water contains, and it is therefore the source of the deposit which is

made in the harbor and that deposit to-day is apparent in many respects; it has compelled the Government to look for a channel through the Bay to provide for the vessels coming into New
116 York harbor, and the Government located Ambrose Channel; Ambrose Channel was built at a great expense, and to-day Ambrose Channel is threatened by this operation of the tide, and when that tide comes back it drives this whole body of water up in the direction of the different piers and docks around Staten Island, a lot comes up into Newark Bay, and so this operation goes on.

Now, therefore, when you make your calculations to discharge this sewerage right at the point where this oscillation takes place, and calculate that it is going to produce a self-clearing operation by itself, I want to warn you that it is not possible.

Now, in regard to foreign commerce, you should all know that if there should be an epidemic break out and it should be traced to any location of a sewage outfall in that lower harbor, and this great discharge of sewerage should produce in the atmosphere pollution and sickness there, do you gentlemen know what the effect would be? It would be so disastrous on the commerce of New York that it would be a long time before we could get over it.

Therefore, the Chamber of Commerce is vitally opposed to increasing the deposit of sewage in New York harbor for any reason or from any source. We find that the Health Officers of the State have considered the condition of the harbor and it is now so perilous that they have established this Commission of which you heard from my friend, Dr. Soper, who is the Chairman of that Commission. And that Commission was appointed with a view to
117 seeing whether New York herself could not reduce the deposit of the sewerage which she is compelled to put in these waters at the present time by reason of her position. Therefore, this is no trifling matter. It is a matter of the very greatest important. And I saw that, in the first application which was made to you, they admit there, they offer, I think, if I remember correctly, they offer to pay for the cost of dredging which may be the result of the injection of this deposit into the harbor; that is an admission on their part that the deposit is going to take place from it, and I consider that it cannot be avoided, and the deposit will necessarily take place, and that deposit must spread itself more or less into the channel. This place of deposit is right at the head of one of the main channels that go in and out of the harbor and any deposit that takes place there will tend to encroach upon and deposit in our great new channel, Ambrose Channel, as it is called, which is an absolute necessity to accommodate these great large ships which come here and bring to us the remarkable and fruitful results in money and passengers and freight shipments.

And my object is to simply repeat to you that the Chamber of Commerce places the utmost confidence in your Commission; they feel that you are going to examine this matter carefully, conscientiously and with the full view of the future and of the facts; that what you are authorized to do is to object to any action which has

for its possibilities a deposit to injure the channel, or any other injurious effect upon the City and Harbor of New York.

118 We therefore look to you with great confidence, that you will examine every fact connected with it, and that in your report, if you will join us in the view that it is not to be granted, you will undoubtedly make such a report to the Secretary of War. Other than that, of course, it remains to be opened to examination from time to time.

One of the greatest difficulties with such an enterprise as this is this: These gentlemen indicate to you all their precautions by which they hope to do away with the evil effects of this pollution, and yet, when you have given them the permission to create the plant and to adopt the measures which they wish to do, there is no possible way you can get your remedy. What are you going to do if you find that it does not operate as they wish and deposits do take place and are reported upon. You cannot make them undo it and destroy this great thing which is going to cost a number of million dollars.

Now then, before you grant the request, if there is a possibility of its coming out or going that way, you are incurring a fearful risk for the City of New York, and, therefore, I must beg you most earnestly to examine that, and if you have any doubt, that doubt should be on the side of the contrary view of the whole subject,—it should be denied.

I approached this meeting with a positive conviction, after reading a history of the different processes adopted in Europe; that there

119 the question had become so very disagreeable that in the City of Milan,—a City, I think, of one hundred and fifty thousand inhabitants, the stenches were so great from the river that the people could not walk on the wharves with any pleasure.

Then, the City of Berlin adopted a most wonderful process, and the City now makes money on its sewerage. The water is drained off; the solid matter is expunged from it, and then put through a process and formed or made into cakes, and sold as a great fertilizer, with the result that the City is to-day in receipt of a larger interest—or of interest on a larger amount, greater than the whole cost of the plant, although it was a very costly plant. The same thing is taking place in the cities of England and elsewhere, and I feel, gentlemen, if you will examine into the various details and note the different steps which have been taken in Europe, you will find that there is a great variety of measures that can be adopted from which I fully believe these gentlemen can get their relief in some other form.

Col. Knight: Mr. Higgins, a very strong part of your remarks, or one very strong feature of your remarks, is that question of trying to prove from the barrel theory that this sewage will not find its way to the sea, but will oscillate up and down the waters of New York harbor.

Mr. Higgins: Yes; permit me,—I did not cite the barrel instance except as a curious fact, a fact which was told me yesterday by one who had watched the fact.

Col. Knight: That was to show that if that barrel never gets out

to sea, if it oscillates right up and down in the tidal current,
120 you would never get any of the deposit into Ambrose Channel?

Mr. Higgins: I beg your pardon; this was a surface test,—the deposit on the bottom could get into the channel in a variety of ways.

Col. Knight: When it comes to the deposit on the bottom, we find in a special report, that according to an analysis of the movement of the water in the harbor——

Mr. Higgins (interrupting): There is not one of them that can be relied on. I state emphatically what I know about the tides; what I have learned from my pilots, which is diametrically opposite to those analyses.

Col. Knight: I wish every argument of that sort could be so readily disposed of.

Mr. Conkling: If the Board please, I am the president of the Realty League of the City of New York, an association of property owners, chiefly in the Borough of Manhattan, for mutual protection, they meet periodically, and at the last meeting this thing comes before us. So, I appear as the trustee of several estates worth several million dollars.

This matter of the sewage is a very serious problem. I might call the attention of the Board to the City of Berlin, Germany, with a population of about two million, and the City of Birmingham, England, with a population of about five hundred thousand, or nearly as large as the population of this entire Passaic Valley. There, they have a large sewage farm, which solved this question very easily. Does the Board know about Tuxedo Park, in
121 Orange County? I suppose not. That is some thirty-five miles out; it is North of Paterson about twenty miles; there, the drainage of one hundred and ten cottages flows into a system of septic tanks, and screened, and treated and disposed of; the system has been in use there for twenty years, and there is no smell of any kind, not even the remotest character; I was there yesterday, and have been there in hot weather and cold weather, and there is never any smell at all from that sewage disposal plant. Then, there is the State Asylum, at Morris Plains, New York, about thirty miles from here; they have a sewage farm there about a half a mile from the hospital; Morris Plains has a population of two thousand at the present time; I was there a hot day some time ago and there was no smell from the sewage farm whatever, only a half mile off, on a hot day.

Instead of polluting our Bay here by this sewage, there is some other method of doing it. As a New York man I should not say what, but perhaps the Hackensack meadows would do for the location of the sewage disposal plant. I crossed them yesterday, and didn't see a house for several miles, and if they can have a sewage farm within half a mile of Morris Plains, there seems no reason why they could not have this kind of a plant there on the Meadows and no one would be bothered by any smell; they could have a purification, filtration, clarification or any other "ation" necessary and put the stuff in such shape that the water could be discharged into

the Hackensack or Newark Bay without any damage to the Harbor.

122 Mr. Harrison said, I think, at least one of the speakers, that it would be more expensive to have a sewage farm or sewage area than to build the proposed trunk sewer: Aye, gentlemen of the Board, there's the rub! More expensive! The four million people of Greater New York must not suffer for six hundred thousand in the Passaic Valley!

I regret my duty calls upon me to oppose this scheme; but it will not do! We cannot stand it! Our interests are too large here. This Association which I represent owns property in the Borough of Manhattan alone worth about Two hundred million dollars. That is a great interest to have in real estate, and we claim that our stores, our houses, our theatres would be damaged by this proposed sewer. If the Board might like, I will submit to you a written statement in regard to the matter. I thank you for your attention. I am ready to answer any questions on behalf of the property owners as to our interests, our warehouses, our stores, our wharves.

Mr. Monk: Mr. Chairman and Gentlemen: This is a subject, Mr. Chairman and Gentlemen, that I have studied and practiced for nearly fifty years in New York City. With almost sixty years of experience around this harbor, and, with no offense to the gentlemen who represent New Jersey here in this application, I do not think, Mr. Chairman and Gentlemen, if they knew the sewage conditions of this harbor they would make that application.

I represent to-day, gentlemen, the Taxpayers of the upper part of the City and from Kingsbridge to Ward's Island on the Har-

123 lem River, from Ward's Island to Sandy Hook and from Yonkers to Staten Island take the Jersey Coast to Tappan Bay,—that forms the tide of the Hudson and on this tide flows the sewerage on the New York side of the Bay, on the New York side,—the New York shore. That forms the bank of sewage, of solid deposits on the New York side and New York City, and around the New York shore.

Take the average soundings in 1893 from the pier at the foot of 42nd Street North River to Pier 11 East River, on the 16th day of May, 1893,—the soundings on the heads of those piers was twenty-six foot of water, and on the seventh day of March of the following year the soundings were nineteen feet; two-thirds of that raise was caused by the sewerage from the bulkheads under the piers.

To give you another idea of the amount of sewage that is discharged, take the piers of the East River, with their box sewers, the plank they run on the brick work of the bulkhead,—those are supposed to convey the solid stuff and the soft sewage into the tide waters, but it does nothing of the kind. Those piers are vast piles of it that is not carried away, and they open the bulkheads and let it out.

I have been reading of the sewage being discharged in the tide water; it is discharged into the bulkhead, and, to give you some idea of the cost, the City paid in the year 1903, the sum of Seven hundred and thirteen thousand dollars to a few concerns in the City to

dredge the bulkheads to fourteen feet of water on the East River.

124 Now, gentlemen, take it around from Astoria, Long Island City, Greenpoint, Williamsburgh and Brooklyn, the hundreds of sewers, all the number of them, and the way they are discharging into this river, not taking account of what is discharged from the sewers on the New York side of the East River, and look at the condition of the water here at very low tide (referring to map). Go from there to Harlem, from Ward's Island to Kingsbridge, and it is really disgraceful to the City of New York to see the condition of that water.

I remember the time, gentlemen, when you could go in twelve feet of water and you could see the pebbles on the bottom of this river. You cannot do it to-day, and it is only possible by keeping a dredging machine going almost steadily over opposite Jersey City, to Robbins Reef, Spring, Summer and Fall, to keep a channel in so much water so that the vessels can get up to their piers. Those are the evils where the solids are discharged and it does not get beyond the pierhead.

Now, gentlemen, I would not advance this argument in opposition to the views of the gentlemen from Jersey only I know that other means can be adopted to discharge the sewage, and not South of the lower Bay, close to the tide water. As the gentleman remarked here that the sewerage can be discharged at a depth of forty feet, why not discharge it in a reservoir and pump forty feet of water up into the reservoir, by a stationary pump, and treat it there and

125 discharge it by land, over land, at ebb tide, and have the openings closed so that none of the discharge would go into the flood tide.

I intended to bring you, gentlemen, a design I had made, twenty years or more ago, for the purpose of conveying the sewerage of Jersey City to Gravesend Bay, and that sewer was to be able, according to the plans, to run paral-el with the East and North rivers, forming a combination sewer here below the Battery, with no discharge along the shoreline until we got to Gravesend Bay. Now, gentlemen, that means for all time. It don't mean for the present. Look at what is coming. Go back fifty years, with a population of three hundred and fifty thousand in New York City, and see where we are to-day. You are granting this permission for all time, and we all know that that harbor is not in condition even to-day to receive the sewage that is going into it. I beg of you, gentlemen, in the interest of the City of New York of which I am here as representing a part of it, that that application will not be recognized by any intelligent body of men.

Col. Knight: Will you kindly give us a little more detail about that sewer that was to go down to Gravesend and be discharged at Gravesend Bay? I do not care about the construction of it, I mean about the discharge into Gravesend Bay?

Mr. Monk: I designed the sewer, I think, twenty years ago; I also designed a sewer to take the place of our present box sewer, but because of the conditions here as to political affairs—

Col. Knight: I would like to know about the discharge—the details of the discharge into Gravesend Bay?

Mr. Monk: Those sewers were to be run in a parallel line—

Col. Knight: Never mind.—coming down to the mouth of it—

Mr. Monk: In to a parallel sewer,—the nearest point of discharge would be Gravesend Bay—nothing along the shore line: The nearest point there is, of course,—you take Bay Ridge—

Col. Knight: As I understand it, you were going to carry out this parallel sewer to be formed into a combined sewer below the Battery, and you were to carry out the sewage in this combination sewer, into a reservoir,—

Mr. Monk: And pump it out on the first of the ebb tide—

Col. Knight: Then you admit, from that, that the flood tide does no injury?

Mr. Monk: No, sir.

Col. Knight: How far will the flood tide carry this sewage?

Mr. Monk: From seven to nine miles.

Col. Knight: From seven to nine miles, that is the limit?

Mr. Monk: According to the way the wind blows there will sometimes be a difference amounting to a total of fourteen or fifteen miles.

Col. Knight: Never further than fourteen or fifteen miles under the most favorable circumstances?

Mr. Monk: Except when it gets into deeper water, beyond the action of the tide into the harbor. That is the object of most of these cities seeking to get their outfall beyond the tidal action.

Col. Knight: But did I understand then, that if all the effluent of this harbor were discharged at Gravesend Bay, it will not be carried back to the City, unless it be carried by the flood tide?

Mr. Monk: It will not be carried by the flood tide—

Col. Knight: You won't let it go out by the flood tide?

Mr. Monk: Yes, sir.

Col. Knight: The influence of the flood tide will only extend about seven miles unless there is a high wind and then double that distance at most, about fourteen?

Mr. Monk: Yes, sir.

Col. Knight: That would be the positive limit of any injury to the interests of the City by the tide carrying this sewage under those conditions?

Mr. Monk: So far as that is concerned, the tide, as it is in Boston—

Col. Knight: I am not talking about Boston, but here—

Mr. Monk: If you draw this (indicating) as the way the water goes the sewerage, I presume you will get some of it over here (indicating). If a pump, a stationary pump be placed opposite this reservoir—this reservoir is forty feet in the air, lifted up forty feet, and the sewage is discharged about an hour before the ebb tide, it will go through and it will not come back.

Col. Knight: Then, there is no reason, with these control gates that they propose on this application here, why they should not make

the discharge then, at the first of the ebb tide, and remove all your objection to the use of the sewer?

Mr. Monk: My good man, they would not get far enough off if the discharge is made in the harbor. Now, then, as I remarked, I designed a sewer, in place of the present box sewers and as I have given this matter considerable study, and inasmuch as I thought it my duty as a citizen and taxpayer of the City to come here to give you my views on certain facts, and I know that I am speaking facts here to-day as to the condition of this City and of New York harbor. The position of that harbor is most disgraceful. The odor that arises from low water from the first of June to the first of October is horrible, and to a measure due to bad laws and bad legislation. If the waters of the upper East River had been safeguarded fifty years ago, it would to-day be fifty feet wider—one hundred feet wider, but then you could not get the riparian owners to put in the proper sewers, if they had done that, instead of putting in the bulkhead sewers, they would have done something for the City, they would not have more water. And now, as you go through Little Hell Gate, and through the large gate and to the point about seven hundred feet beyond, where they are now building another large city, you will see what I refer to, and in thirty-five years from now the same will be true in Flushing Bay as you see here; and, again I ask you, gentlemen, as intelligent men, to study this question carefully before granting this application.

Mr. Colyer: Mr. H. R. Towne, President of the Merchants' Association, noted on your memorandum, has been unable to come and desires to have it understood that he would have been here under other circumstances.

Mr. Ring: Mr. Chairman and Members of the Board: I appear here as representing the New York Produce Exchange and I think I can also speak for other commercial bodies in the lower part of New York City. I think that the Produce Exchange has as large an interest in this matter as any other body of people in the City. We are located right at the lower end of New York, close to the water side; we have a large membership and a very large attendance; our offices are located in this section of the City and quite close to the point, or as near as any part of our City, to where this sewer is expected or intended to make its exit.

I come here, representing the Exchange, and enter our earnest protest against any permission being given to this sewer that is proposed by the Passaic company, simply because at the present time we empty our own sewage into the river is no reason why we should empty an additional quantity; on the contrary, as you have already been told to-day, measures are being taken or being considered whereby the sewage of New York City in course of time will be taken care of and will not be dumped into our bay and into our harbor. That time, I believe, is not very far in the future. It is a large subject. Of course, it is harder to remedy a thing than it is to make it right in the first place, but it will come.

Now, I wish to give you an illustration ofwhat can be done with a sewerage farm, and that I know of by my personal knowledge.

It has been stated here, I think, by one of the engineers, or at least one of the representatives of our New Jersey friends, that no system has as yet been discovered that will give perfect sewage sanitation and disposition. I take issue with him on that.

In 1889 I visited Australia and the City of Adelaide, a city of one hundred and fifty thousand inhabitants, had just incorporated a sewage farm. I was interested in it, naturally, and I visited the farm with some of the officials. It was located, as I recollect, about five miles outside of the City limits; a trunk line sewer conducted all of the sewage from the farm to this plant. The sewer, as it reached the plant, was taken up in large circular tanks and the water passed through certain sieves, that, I do not know what the substance was, but it took out all of the solid material; when I say all, I mean all absolutely, not a portion, and when it was taken out, that water came out just as clear as crystal, there was not a particle of sewage you could detect with the naked eye, and that water I saw, I looked at it and it was as clear as crystal, you could see it run through in the sewage ditches where it is taken out to irrigate the farms, and the water as I have said is as clear as crystal; no sewage in it. Now, as to the sanitation of it, how it is accomplished, I do not know, but by some chemical process or by the addition of some substance, it was rendered entirely sanitary and the material that was taken out was put into shape for fertilizing purposes, and it was distributed all over the farm; and I wish to point out to you that inside of four years that farm was quite self-supporting and was a revenue producer; that was in 1889, and it has continued so ever since, and there has never been a complaint of any kind.

Now, as to Melbourne, when I was there they had an epidemic of typhoid fever; I visited the city a number of times but quickly got out of it, whenever possible. The Yarra River was in a condition of similar at that time to what you say the Passaic River is now; it was crooked, dirty and smelt bad; it was a vile stream; the sewage was run into it and nobody wanted to be any nearer to it than anybody could possibly help. I arrived on a hot day, when to be near the river was almost over-powering. The epidemic of typhoid fever started the people to taking up the sewage system on lines the same as in Adelaide as might be necessary to be done. They bought property located within ten or fifteen miles of the City, and then Melbourne built a trunk sewer down to the farm, and inaugurated a similar system of sewage disposal to that at Adelaide, and only yesterday I talked with a gentleman from Melbourne, on this subject and he told me that the sewage farm was an absolute success; that it was a paying proposition; that it produced a revenue, that it purified the sewerage to such an extent that the water that came from it after it passed through this sewage process was absolutely clear and that it was not only clear but was so chemically pure that it could be drunk without any danger to any one, and that they sold the solid matter after treatment for fertilizer; which corresponded to what I saw when I was at the farm at Adelaide, and that same system, accordingly has been put in at Mel-

bourne and has worked admirably in both cities since. Now, I say that the United States or any city in these United States that cannot be up to modern ideas equal to those used away off in Australia is a pretty poor sort of a city, and, when the engineer or gentlemen comes here and says that no system has been ascertained or devised that has proven satisfactory, I take issue with him directly.

I wish to speak to you on another point. I come here as a practical steamship man, and have been in that business for many years. I know that the sewage from this City does fill up our harbor. We have loaded steamers at various piers here, and we know that whenever we have to go near a pier where there is a sewer that empties into it, that place has got to be dredged out every three or four years, and the steamers frequently run aground, and we are unable to unload them in such piers because there is not a sufficient depth of water and this is true not only in the official piers, but
133 privately owned piers, and we have dredged out many places for steamers to get out and not only that, but we have to wait for high water to get them to the piers. Take, for instance, along about Depew Street, Brooklyn, you cannot load steamers there drawing more than three or four feet, because of the large sewage deposits under which we labor at that pier.

I come here because of a double interest in this matter, and I do not think that simply because it is a matter of economy for the Passaic Valley boroughs, villages and cities, located in the Passaic Valley, that we should permit this imposition of emptying this sewage into our harbor when they can establish sewage plants there and can get rid of it. If the gentlemen think they can put the sewage into the condition they are going to and that in such a condition it will not cause a deposit or a nuisance, why not dump it into Newark Bay? We don't want it over here. If it is not a bad thing, let them keep it. We don't want it, and on behalf of the Produce Exchange of New York City, and I speak as a member of the Chamber of Commerce, I enter my strong protest against any permission being given to this scheme for sewage to enter into New York bay.

Captain Parsons: Somewhere about six years ago, the question of sewage was brought to the attention of our Maritime Association, of which I was at that time President, and we were informed then by the Metropolitan Sewerage Commission that, in twenty-five years, with the continuation of the same conditions which had
134 prevailed for the past few years that the harbor of New York would have reached the danger point for navigation from the sewage. One-quarter of that time has now passed, and we are that much nearer the danger-point, but we are nearer than that from the fact that the amount of sewage has increased in a greater proportion than previous to that time. I am here I suppose, to-day, to represent the sailing vessel interest more than any other one particular interest. I occupy a rather anomalous position, because I regret that I am here to oppose what New Jersey men feel as their interest, yet I am a New Jersey man myself, but I feel, Mr. Chairman, that no man, living along the Passaic Valley can divorce

himself from the best interest of the City of New York and of this harbor. The interests of the people living within fifty miles of this City are so closely allied with those who live here and do business here continually and are New Yorkers, that it is impossible to separate them, as no man can to-day in any way injure this harbor, if he is doing business in any way with the City of New York, without to some extent injuring himself. Therefore, I feel that the people who have charge of this sewage question would be unwise to make any arrangement incurring any extensive expense which would result in adding pollution to this already over-polluted harbor; but some method ought to be adopted, as has been suggested by the President of the Produce Exchange, my predecessor, to dispose of this sewage without injury to the harbor.

One of the gentlemen who has spoken since I came into
135 the room, said he had been familiar with this harbor for the last sixty years. I have a very distinct recollection that about sixty years ago the people dealing in fish in Washington Market were obliged to take their fish cars out of the slip from the fact that the water had become so polluted that the people who desired to eat fish in the market or buy fish from the market would not purchase them, feeling there was no assurance that while they might have come direct from sea, there was no assurance they had not come from those water-soaked, polluted fish cars, and consequently they were obliged to find some place for their cars where at least they were not in *side* of their patrons; and this was sixty years ago.

One of the points which we object to, those who, of us, are interested in the affairs of New York harbor, is that it affects the navigable capacity of the harbor, and it obstructs it, as has been alluded to by my predecessor, by filling up the heads of the piers, shoaling the slips, which are used for anchorages for small craft or vessels where the channels are in the strong and rapid flow of the tide, if the tide flows across the channels, as is frequently the case, then they fill up very rapidly with this sewage. It is also a detriment to the navigable capacity of the harbor from the fact that these bays, little arms of the sea, as they may be called, rather more than rivers, show pollution to such an extent that it is injurious to the vessels and their paint, both outside and inside, is so affected, that if a vessel
136 painted white be remaining in some of those waters would have become lead-color in a day and if there two or three days, nearly black. This has prevailed to such an extent that the yacht owners will not consent to send their vessels anywhere along the Brooklyn shore during the Summer season, as it implies an entire new coat of paint, and it is not only the outside that it affects, but stains the inside. The other point is that it is absolutely unhealthy for crews of vessels to remain on board while located in the territories or localities where this has been so offensive, and this is continually increasing.

I feel, therefore, that we, of the sailing vessel interests, and while the foreign sailing vessel interest is rapidly disappearing, yet we do have a large coastwise sailing-vessel interest which is worthy of some

2969

attention and some respect, and that the merchants who are doing business by using those sailing vessels are also interested in that which pertains to their welfare, and I do most seriously and sincerely trust that some arrangement will be made whereby this vast amount of sewage, which it is proposed to be emptied into the Hudson river out of the Passaic sewer, can be provided for in some other way.

Mr. Riker: I trust that Mr. Dean will be confined to questions which are directly relevant to this issue,—that is, whether the proposed work will interfere with navigation. One of the questions between the State of New York and the State of New Jersey is
137 whether it will be a nuisance, and I do not want the witnesses we are to use in that suit cross-examined on anything but what is relevant to matters of navigation.

Mr. Lebkuecher: If there is going to be some cross-examination, it seems to me that we might also with propriety ask the speakers on the other side in reference to some of their statements which they have made and which we think——

Col. Lockwood: I do not like the expression "cross-examination"; I think you had better "question" the witnesses or the speakers.

Mr. Lebkuecher: We think that some of their speakers also made some statements which will not be borne out by the facts.

Mr. Dean: I am perfectly willling to have the gentlemen we called or will call questioned by the gentleman representing the Passaic Commissioners. We have special witnesses here who have not yet spoken,—one is the Consulting Engineer of the State Board of Health, and experts on sanitary matters, generally informed on this subject of disposal plants, and it is with these gentlemen we expect to take up the technical side of the case for you, if you wish to go into it. Of course, the other gentlemen who have spoken, have spoken as representing various interests.

The Chairman: I take it that this asking of questions is for the purpose of furnishing the Board with more information, and I will say that to that extent and for that purpose the questions may be limited.

138 Mr. Riker: We most respectfully object to any questions being directed to the gentlemen who have presented the case for the Passaic Valley Sewerage Commission by any person other than the Chairman or members of the Board: We have produced the most eminent gentlemen; the gentlemen will be witnesses for the State of New Jersey in the litigation now pending between the States of New York and New Jersey and should not be questioned on matters involved in that suit except in the litigation of it. These gentlemen will be glad to answer any questions which this Board may ask. This gentleman, who represents, as I understand, theoretically, the State of New York, is the same gentleman who drew the bill that has been filed in the United States Supreme Court, and for him to go over our witnesses and ask questions which this Board do not want to ask, I think is eminently unfair.

Mr. Dean: I have no desire to get any other expert testimony from Messrs. Hering or Harrison if they will bring out plans in detail. I want to find out if there are any more definitive plans, any

better defined plan with reference to their proposal as to sedimentation, and screening, in order that we may be able to learn exactly what proportion of the solid matter they propose to remove, and how. They have stated that there will be no deposit, and that they intend to discharge the sewage in a liquid form and that it will be readily dispersed. If they will furnish us with specifications showing their definite plans for the accomplishment of these results——

139 Col. Knight: I might say that there are no definite plans; there is no use questioning for definition of plans. You can see from their application just what the specifications are which we have before us.

Mr. Dean: That is what we are after. They have not furnished specifications, although we have been endeavoring to learn from them what they propose to do, we have not been able to get any information. We want to learn the proportion of the solid matter, and the matter in suspension they propose to remove, and how it is to be done. We want to find out the size of their sedimentation tanks, the size of the screen; and they have not, as I have said, furnished this information; therefore, I have desired to question them in order to ascertain just what their application is for, with a view to determining what the effect on the navigation of this harbor may be; what we want is something to go on.

Col. Knight: If you can throw any light on the sedimentation process, and upon the quantity of solids to be removed, we would be very glad to get the light, on the sedimentation, on the removal of the grit——

Mr. Dean: My first question is in reference to the grit chamber.

Mr. Harrison questioned by Mr. Dean:

Q. Will you explain in detail the size of the grit chamber, in your plans, as you propose to build the sewers?

A. The size of the grit chamber will be sufficient, in the
140 opinion of the United States authorities to do the work or remove such an amount of grit as is necessary to prevent any obstruction to navigation, and we have so stated, sufficient to do the work, reserving to the United States government the determination of its sufficiency, and nothing done in the completion of our work will affect the navigation interests or the interests which the United States has, under the Constitution; and all will be done subject to the approval of the proper authorities of the port of New York; the plans will be submitted to them, as was stated in our application.

Q. As I understand it, the purpose of your petition before this present Board is to present your plans in detail, to show them how much solid matter will come out of the sewer, and go into the water?

A. You are very much mistaken as to what is the purport of our proposition; the object of our petition as is shown by the application,—we have proposed to put a structure in the soil of New Jersey, under the waters of New York and Newark bays and at certain points shafts, and so on; that structure will rest upon land of the state of New Jersey, and on land deeded by the State of New Jersey to the United States, in which New Jersey has the reversionary right——

Col. Ruffner: I object to this altogether. The Board likes to get information, but we are not here to settle points between one State and another. I think if the Board wishes to ask questions, if there are any doubtful questions, but if other gentlemen have doubts about it, this is not the place to settle them. I object. The Board
141 is not asking the questions.

Mr. Dean: May I present my side of the argument?

Col. Ruffner: You may make a statement of your own point of view, as much as you choose,—you can question, in your statement, the statements of other gentlemen, if you wish to, but I do not like to have you ask anybody else for further information.

The Chairman: Mr. Dean, will you please outline to the Board just exactly what it is you wish to accomplish by your questions?

Mr. Dean: I will say that the petition to this Board has been read, but I wish to draw attention to the fact that they request permission for the construction and permanent maintenance of tunnels under the navigable waters of Newark and New York bays, as shown by plans attached, before you. Then it goes on in five or six requests and asks permission to complete—to build a sewer.

Now, the amount of solid material that will come out of that sewer as effluent is very material for us to determine because if it is insignificant then New York can have no objection to the construction of that sewer, but if the solid matter is not properly removed in this screening chamber which they have described to us, that is if the size of the mesh of this screen be one-eighth of an inch mesh it will remove a certain percentage, and we ought to know this percentage, in order that we may be able to determine the result or the probable result of the screening they propose, as it has been determined in any of the different disposal plants where the sedi-
142 mentation system is used; it has also been determined definitely what percentage of solid matter there is in ordinary sewage. For instance, I would like to find out whether this sewer is going to—which is going to dispose of the sewage from these different municipalities, whether it will carry storm water, because storm water largely differs from ordinary sewage, in other words, there is not so much organic matter in sewage in what they call the combined system as there is in the separate system. Of course, in a separate system it takes away the storm water in one pipe and it takes away the sewage from houses and factories in another pipe, and I would like to know if they are going to use the combined or separate system, and as that determines largely the amount of solid matter in the sewage, then I say we can only determine the size of the solid matter, as it differs as explained under the combined or separate systems, by determining how much sediment is to be taken out in this grit chamber, and that, of course, consists of sand and broken up particles of soft organic and mineral matter, and then, when from certain storms they have, the sewage is permitted to run down at a certain rate of speed through the grit chamber, the tunnel is full, the question is, how much is going to be sedimented out, what certain proportion of the detritus can be settled out, and what certain proportion is going to escape? We would like to know how

much is going to be taken out in the settling basin, and by the screening.

The Chairman: Why do you want to know that?

143 Mr. Dean: My point is just this: I don't see how you gentlemen can pass upon such a plan as this unless you can say, or the experts can say, how much of the solid matter is to be withdrawn from this sewage, how much shoaling is going to be caused in the harbor, the amount of shoaling to be represented by that capacity, by the number of cubic yards of solid matter removed, the number of cubic yards of shoaling per year depends upon the amount of solid matter removed by screening in the screening chamber, in the grit chamber; the whole question, the most important point in this whole proposition, is to find out whether there will be shoaling; if there will be shoaling, then we earnestly contend that this permit should not be granted. If there is no shoaling the only question is whether these dispersion pipes, so called, will be placed at a sufficient depth in the water to permit of vessels passing by at low water.

The Chairman: According to the endorsement of the Chief of Engineers, the Board was directed to take up the question of having any deposited matter or shoaling removed by the people controlling the sewer——

Mr. Dean: Now, if it may please the Board, they have not shown what percentage they are going to remove of solid matters from this sewage——

Col. Knight: Why do you want to strengthen their case?

Mr. Dean: I want to find out——

Col. Knight: Don't you think the mere presentation of a

144 case without giving required details——

Mr. Dean: If they are willing to stand on the 1908 report of the Passaic Valley Sewerage Commission, then I am willing to say that——

Mr. Riker: Put that in your bill you have before the United States Supreme Court——

Mr. Dean: I wish to say that the suit which the State of New York has brought in the Supreme Court of the United States is in no way concerned in this hearing at all. He (referring to Mr. Riker) is now referring to that case. The legal questions will be taken up in that suit, but the reason for the opposing the granting of this petition at this hearing is for fear that your Board will grant a permit without having investigated every detail in this immense big subject, and which, if their permit was granted, would, to a certain extent jeopardize the case in the United States court, in which regard the Department of Justice is here represented by Mr. Miller, and to a larger extent where we are hoping within the next year to have further investigations made, and I might quote from different reports of different engineers, from one engineer especially, Mr. Allen Hazen, considered to be one of the best sanitary engineers in this country, where I believe he says that engineers are themselves *are* very doubtful as to what the effect will be in New York harbor, and it seems to me that the only way we can determine that properly

is to have the Department of the Interior make a complete and exhaustive study of the differences and conditions of the tides
145 in this harbor. I understand that the Metropolitan Sewerage Commission has done some work along those lines, but they have been limited to a certain extent in their investigations, and I think that this matter ought to be fully investigated.

We have had some general statements as to what the effects of the tides are. We learn, from the United States Government report of 1887, that there is an under-run, as stated from their own investigations—in the Government report—which goes up the Hudson river, but that was so many years ago that conditions might have changed, and we wish to investigate all points thoroughly. That is the reason why I wanted to bring these matters out fully. If you will permit me, I have sanitary experts here and I will be glad to have them make definite explanations of these matters for the purposes of this Board. We earnestly request that no permission be granted to these petitioners unless it is after a very exhaustive and full examination of this matter, and I do not believe, from my own stand-point,—the way I look at it, I do not consider that a full investigation can be made of the hearing of this application with what it involves, until these gentlemen can tell us how much solid matter they are going to remove, and that cannot be determined until they tell us the size of the screens, and how they propose to remove the detritus from the screening chamber, until they tell us the size of the grit chamber and how much solid matter such as sand and grit and mineral matter to the cubic yard they are going to get out.
146 They have failed to tell us anything at all—except by their silence—about the grease and soap that will work through the screen. They cannot hope to remove grease by their screens, and yet they say they are going to remove all of the floating material.

You know that in Boston harbor—and I am only making this statement in a general way,—we have experts here to prove it, if you wish to go into it—what the conditions are in this regard. We know that in the Summer time there are obnoxious odors which come off over the polluted area.

In the Government report of the investigation of the Boston sewage problem they state the exact existing conditions which have prevailed there at Boston, although they do not go into as much detail as we would if we went into this matter over here, but we do know that in Boston harbor the polluted area extends fully two and one half miles, and we know that these things exist, and we know that they cannot remove the grease through treatment by screening, and we do not know how they propose to do it. Now, if those conditions prevail at Boston where they have a tidal movement of fourteen feet—I am not positive as to this—in the polluted area, and with the tide movement in New York harbor of between four and six feet—I am not absolutely sure as to that point, and *the* it is an important point, I am going to ask Mr. Harrison these questions so as to bring out how much solid matter they are going to remove through their screens, what is the size of their grit chamber, and as to the effect of the sedimentation they propose?

147 (The following is read by direction of the Board):

"NEW YORK, November 30th, 1908.

D. W. Lockwood, Col., Corps of Engineers, United States Harbor Line Board, Army Building, New York.

GENTLEMEN: I shall not be able to attend the public hearing set for the morning of December 9th, notice of which you have been kind enough to send me.

I would respectfully make the suggestion, however, that whatever restrictions upon the discharge of sewage into *into* New York Harbor or its tributary waters may be finally determined upon, that they should be made equally applicable to communities in the State of New York and in the State of New Jersey. Any attempt at discrimination as regards privileges to be extended to each State can only result in delay and subsequent complications. The first requisite for a proper consideration of this subject is the certainty that the National Government so far as it is able to control the situation will treat each State fairly. If it shall appear that communities in New York State have already, acting in advance of New Jersey,—polluted the waters of the Harbor by the discharge of sewage then corrective measures should be sought for the facts as they exist.

I would respectfully submit that a sewage flow from the East into these waters is just as deleterious as a sewage flow from the West.

Yours truly,

(Signed) CALVIN TOMKINS."

148 "BOROUGH HALL, NEW BRIGHTON,
NEW YORK CITY, December 1, 1908.

Col. D. W. Lockwood, Corps of Engineers, Chairman Harbor Line Board, Army Building, New York.

SIR: The writer has been asked by the Staten Island Chamber of Commerce to be one of its representatives at the public hearing which you are to conduct on the morning of Wednesday, December 9th, in connection with an application of the Passaic Valley Sewerage Commission of New Jersey, for government consent to its constructing and maintaining a proposed great trunk sewer outlet in New York Harbor. He regrets that a prior engagement in Boston will prevent personal attendance, but instead will present the following notes.

During the three years of its existence, the writer was a member and officer of the New York York Bay Pollution Commission, the first official body to take up the question now before your honorable Board, and as Consulting Engineer and Commissioner of Public Works of the Borough of Richmond for the past seven years, has had under observation more or less constantly the conditions of the Harbor as to sewage pollution. In the design and construction of sewers for this portion of New York City under the President of the Borough, the question has been kept to the front and designs have been such as to provide for the future interception of sanitary sewage and the first discharge of storm flows, so that they may be
149 treated and the effluent rendered inoffensive, in-occuous and non-putrefactive.

Properly providing for the sewage of New York City and neighboring municipalities in both New York and New Jersey, is one of the great problems of the day. Much has been said about the shell fishery industry as a factor in the question at issue, and it is important; but aside from that, the comfort and it might be said the sentimental wishes of the inhabitants of New York and vicinity are of tremendous import.

The Harbor of New York and its tributary streams should be kept free from all refuse; floating, suspended or in solution. No community should be permitted to continue to an indefinite future the disposition therein of the solids of sewage wastes. Probably at the present time there is an average of twelve hundred to fifteen hundred tons of deposit daily. Some of it changes by putrefaction into gaseous form and passes off into the water or air, but the greater bulk of it remains as a filthy deposit on the bed of the Harbor, a little perhaps passing out to sea.

The large flow of fresh water coming down the rivers and the tidal inflow of more or less clear sea water, makes conditions safer than in some other of the great sea port cities of the world; but even New York and vicinity cannot long continue to abuse these advantages and not suffer seriously in consequence.

Now, to the point of immediate consideration, the application of the New Jersey Commission to your practically untreated sew-
150 age in large quantities into New York Bay at a specific point or several neighboring points. It may not be strict justice for New York City to continue to do itself what it wishes to forbid a neighbor from doing, but it is easily within the possibility of the New Jersey project to so care for and treat the sewage gathered from a number of localities, that the effluent, which could then be admitted to New York Harbor, shall be inoffensive in-aerious and nonputrescible, or practically so. We do not consider that it will ever be necessary for New York or the whole Metropolitan district to so treat its sewage as to make the effluent pure, but with the results accomplished as suggested, and readily possible, diffusion, marine organisms and chemical action of the sea water will effectually care for all that remains, so that the harbor will be kept pure and clean.

We therefore would protest against any consent being granted to the Passaic Valley Sewerage Commission, that is not coupled with the absolute provision that such sewage as may be permitted to enter the harbor shall meet the foregoing requirements.

Yours respectfully,

LOUIS L. TRIBUS."

Mr. Harrison questioned by Mr Dean:

Q. Mr. Harrison, I refer you to the special report of the Passaic Valley Sewerage Commissioners to the Governor of the State of New Jersey submitted June 8th 1903 and on page 13 read you the following which appears over your signature: "Experiment and
151 experience have shown that in the sewage of Eastern American cities these one hundred gallons per head will contain about one-one-thousandth part of organic matter and about the same

of inorganic or mineral matter, or about a little less than one pound of organic matter to each person per day."

A. That is according to Rathbone's measure, also the Royal English Society; it is less than George W. Fuller's investigation made in the last few years, but according to Roesler & Becker, on Sewage, that is about right; it is also in the investigation of the Massachusetts State Board of Health—that was about their figure.

Q. In other words, there is two parts per thousand of solid organic matter——

A. No, one part of organic and one part of mineral.

Q. Making two parts of solid matter altogether?

A. Two parts per thousand per person.

Q. Do you *subscribe* (agree) with Mr. Hering in a statement he made this morning that the sewage would consist of one part in five thousand?

Q. I did not hear Mr. Hering make the statement; besides, the sewage of Paterson is heavier than that; Orange is also heavier than that. I think that what he said must have been that it was no heavier than the average eastern American standard.

Q. I understood him to say that the sewage which would enter the grit chamber would have solid content of *one* (five) part in one thousand?

152 A. That may be his judgment.

Q. Engineers are not agreed on that?

A. Neither are lawyers; it is a question technical.

Q. What will be the amount of sewage, in gallons, which will be the ultimate capacity of the sewer?

A. The ultimate capacity of the sewer——

Mr. Riker: Does the Board want to go into that matter, it has been covered by the direct statement?

Col. Knight: That matter has been covered by direct statement this morning.

Mr. Dean: The reason I am asking the question is that I did not consider the statement they made this morning corresponded with the statement they made in their report. Their report says that the trunk sewer will have an ultimate maximum capacity of three hundred and sixty-five million gallons per day, and that the average daily sewage would be three-fourths of that amount; this morning they stated that it would be two-thirds of this amount, and if they are going to try and build——

Mr. Harrison (interrupting): Let me answer that question in regard to Mr. Hering. Mr. Hering gave you the amount of solids in the water which come right through the sewer; I have given you the average American sewerage, of one hundred gallons per head per day, that it would be made up of one part in one thousand of organic and one part in one thousand of mineral solids. The water that will go through this sewer will be two hundred gallons per head and sometimes three hundred gallons per head.

153 Mr. Dean: As I recollect it, the basis of calculation stated in your 1908 report was one hundred gallons per head——

Mr. Harrison: No; you are not correct. The house sewage was stated at 150 gallons per head, ground water leakage of the Passaic River, one hundred thousand gallons per square mile, East, and seven hundred thousand gallons per square mile; trade waste not exceeding ten per cent of the amount at the lowest. What the trade waste will be in 1940 is properly a calculation of averages.

Mr. Dean: Gentlemen, I can see we are going to have great difficulty in getting the information we require; will you please try and establish by the witness any definite statement given as to this plant?

Col. Knight: That is all before this Board; now, then, you differ with him on the question of the solid content; regarding these averages, and so on. Now, then, you have his statement, and you have the statement of Mr. Hering. If you have anything to gainsay it, why not bring it out by evidence? We are informed of that——

Mr. Dean: If they do not agree in certain material respects possibly we could make them agree by showing some other——

Col. Knight: I do not think this Board would care to have a forced agreement. We have these two statements giving the maximum and minimum of the solid material they can get out of the sewage and that will go into the water; if these things are wrong, why not
154 establish it by witnesses and give the Board the truth in the case, give the Board the true figures, bring out the facts of these proportions of solid matter. It may well be, as you can readily see, that if that proportion should be so small that distributed over an indefinite area it will not make a deposit of an inch in years, there is no interference with navigation, so that, how much you are going to remove is getting the cart before the horse, if there is not enough there to effect navigation, whether you remove one-tenth or one-quarter of it is immaterial.

Mr. Dean: Well, then, Mr. Harrison, do I understand that the statement you made about the average sewage of the average American citizen is applied to the sewage as it will come down this trunk sewer?

Mr. Harrison: It probably will; that is the statement which is accepted by engineers throughout the country and is about right; two parts to one thousand, the normal constitutents of American sewage.

Mr. Dean: Then I do not understand your answer to the question about the average number of gallons ultimate capacity.

Mr. Harrison: The average ultimate capacity we assumed would be for a population of one million five hundred thousand estimated to be reached in about 1940. We cannot keep out of that sewer a certain amount of the ground water, and we estimate that the ground waters are to come in and will practically add eighty per cent to that one hundred gallons a day for the population of one million five hundred thousand, their sewage, eighty per cent of the
155 ground waters that we cannot keep out, perhaps some factory waste and that will make an ultiamte average capacity for the sewer of two hundred and fifty million gallons for which we provide a sewer which will carry about three hundred and sixty million gallons because from four o'clock in the afternoon—in the morning, until four o'clock in the night perhaps, the sewer will run

a maximum which will be double the minimum at four o'clock in the morning but the sewer has got to be big enough to carry the maximum, the peak of the flow.

Mr. Dean: Do I understand that the Commission has not adopted any definite plans as to the grit and screening chamber?

Col. Knight: I do not think the questions are material. It is not necessary to go into that; whether they have adopted those plans or not, we do not care; that is already before this Board.

Mr. Dean: Mr. Harrison, has this commission investigated fully all of the alternatives which may be adopted?

Col. Knight: I object. It is not the question before the Board, how many alternative they may have studied; the question is whether the permit be granted to this Commission for this sewer as affecting navigation.

Mr. Dean: Will you tell us, Mr. Harrison, the depth of the height of the sewer of the top of the sewer below New York Bay where you propose to erect the shafthouse?

Mr. Harrison: At Robbins Reef?

156 Mr. Dean: Yes.

Mr. Harrison: Below New York Bay?

Col. Knight: We have got the profile of this proposed shaft-house; that is on record here; that is established by the application.

Mr. Harrison: The statement made in our application is that the bottom of the shaft will be forty feet below high water reserving the right to go lower.

Mr. Dean: Mr. Harrison, the plan you have submitted, is that the final plan for the construction of the sewer under New York Bay?

Mr. Harrison: I guess not; we will probably spend one hundred thousand dollars or so before we get the plan final.

Mr. Dean: Then you would not state that the sewer will be so many feet below high water, or will be so many feet below mean low water?

Mr. Harrison: Yes; we have; it will be at least fifty feet; maybe sixty or seventy—the State of New York is not interested in that; it will be in the lands of the State of New Jersey——

Col. Knight: He has given a minimum there, reserving the right for a maximum. There are two conditions there——

Mr. Harrison: Those conditions are apparent on a rainy day—those are only minimum conditions; there will be a maximum of that.

Mr. Dean: Coming back to the storm water, just how much
157 of the storm water is to be taken through this sewer?

Mr. Harrison: In general, part of this Passaic Valley Sewerage District territory now has a separate system and another part has a double system; it is the purpose that the whole territory shall be equipped with a separate system; the only proportion of storm water we will get into the sewer when it is first completed will be the first rush of storm water; then it is proposed to cut this off by automatic pipes and put it into the river, and when we shall have reached that point in the working of this sewer, the community shall put in a separate system very soon; the law provides that the

apportionment for maintenance is to be based upon the proportions of water delivered from each of the communities, so that it will be to the interest of every community to put in a separate system and keep the amount of the sewage down, because otherwise the smaller communities would have to put as much where they have the double system or combined system as the larger cities would, having the separate system——

Mr. Riker: Does the Board feel that this is a matter for them to consider?

Col. Knight: The Board is allowing that answer to go on the record——

Mr. Riker: I thought that I would have an opportunity to object——

Col. Knight: The Board is merely trying to get information. The Board has its object. The Board, I think, will stop whenever they think it improper, as I think it has shown a disposition to do.

158

Mr. Dean: I really wanted to bring out the amount of solid contents which goes into the sewer from the storm water. From the statements which have been made it is impossible to ascertain just how much solid matter there will be in the sewage as proposed to be discharged. I have here Professor Landreth and Dr. Jackson, who tomorrow morning will make a statement here and also give testimony especially with reference to the effect of the sewage on the harbor of Boston, which is particularly relevant because of the expressed purpose of the Commission to adopt in a modified, and improved, form, the system there used.

Col. Knight: You will be prepared to show that the sewage in Boston harbor is treated substantially as they propose to treat it by this plan? In other words, if you are not so prepared to do, your statement as to Boston Harbor won't have any bearing——

Mr. Dean: That comes right back to the capacity of the grit and screen chamber; the only thing I can do is to suppose there is a similar or equivalent treatment——

Col. Knight: You will be prepared, when you make the comparison,—you will be prepared to explain the Boston method in detail?

Mr. Dean: Yes, sir.

The Chairman: It is now a quarter of four, and the Board will stand adjourned until ten o'clock tomorrow morning, December 10th, when it will hear anything further that may have to be offered on this subject.

159

Second Day.

December 10th, 1908—10 a. m.

The Chairman: Gentlemen, if you will come to order, the meeting will open.

A letter was received this morning by the Board: I will read this letter as it came to the Board:

"NEW YORK, December 9, 1908.

New York Harbor Line Board, 39 Whitehall Street, City.

GENTLEMEN: Having attended this morning at the hearing on the subject of the Passaic Valley Sewer, and understanding that you will not be able to hear arguments from individual associations, we respectfully ask you to note our appearance on behalf of the Sea Gate Association and of the Atlantic Yacht Club, both at Norton's Point, in opposition to the plan of constructing a sewer, as described this morning by the engineers of the Commission.

From our observation of the water, especially in Gravesend Bay, we are convinced that, if any change is made in the handling of sewage, it should be a radical one, and on the lines described by the Commission's own engineers this morning, as existing in Berlin and Paris. We are of the opinion that, if Newark wishes to change its method of disposing of its sewage, absolutely no sewage from that city and the adjoining cities should be in any manner discharged into New York Bay.

We are yours very respectfully,

BARTOW S. WEEKS,
Attorney at Law, Representing the Atlantic Yacht Club, 2 Rector Street, N. Y. City.
GHERARDI DAVIS,
Attorney at Law, Representing the Sea Gate Association, 44 Pine Street, N. Y. City."

The Chairman: The first part of this letter was evidently inspired by a misunderstanding of the situation. I do not recall that anything occurred yesterday that indicated a desire on the part of the Board not to hear any one who had anything to offer on the subject. The gentlemen were communicated with by telephone this morning and the misunderstanding is corrected. They were convinced that they were wrong in the statement they make in the commencement of the letter; they also requested that the letter be read and form a part of the record, which will be done.

The next letter is dated:

"WASHINGTON, D. C., Dec. 8, 1908.

Captain Parsons, 6 Coenties Slip, N. Y.

DEAR CAPTAIN PARSONS: I regret it will be impossible for me to be in New York at Harbor hearing tomorrow. I have written Mr. H. C. Hunter (Sec. N. Y. Dry Dock Ass'n) 30 Church Street, Tel. 458 Courtlandt, to consult with you.

Unless dumping of sewage into New York harbor is restricted the harbor will ultimately be on a large scale what Gowanus Canal and bay are now in a smaller way, an insult to decency and a bar to sanitary and business progress. The City is now spending over a million dollars installing and hereafter will spend annually a large sum maintaining and operating a plant to clean Gowanus Canal and Bay. If New York harbor is allowed to get into similar condition I doubt whether tens of millions would

cure the evil. It will be infinitely better and cheaper to prevent than cure it.

Our Company, the "Yebo Yacht Basin Co." have a large and valuable water front plant at foot of 23d Street Brooklyn, during the past ten years the income therefrom has decreased one half as a result of dumping in and pollution of Gowanus Canal. The sewer refuse settles on the bottom and a gas arises that destroys painted surfaces so rapidly that in hot weather yachts cannot stop an hour in the neighborhood without danger to their decorations and men cannot sleep on board vessels without danger to their health.

The condition at Gowanus has retarded business development for years and caused enormous loss to the property owners in the neighborhood.

Yours truly,

WALLACE DOWNEY."

The Chairman: The following has also been submitted:

"NEW YORK CITY, December 10, 1908.

New York Harbor Line Board, 39 Whitehall Street, New York City.

GENTLEMEN: In order to save the time of this Board dur-
162 ing the conduct of this hearing on the Passaic Valley Sewer, I beg to submit in written form the protest of our City Improvement Society against this proposed sewer. While we realize that this question will be decided chiefly on engineering and scientific grounds, we feel that as a civic organization we should at least register one more protest against what must prove to be a serious invasion of the rights of the citizens of New York City to the enjoyment of life and the pursuit of happiness.

Respectfully yours,

CITY IMPROVEMENT SOCIETY."

The Chairman: The Board is now prepared to hear anything further on this subject that those present may care to offer.

Mr. Dean: Mr. Chairman and Gentlemen, we would like to ask Dr. Jackson if he objects to stating the conditions in Boston Harbor as he knows them as a comparison with the conditions in New York Harbor.

Dr. Jackson: I have been connected, as chemist and sanitary expert, with the New York Bay Pollution Commission, and the Metropolitan Sewerage Commission of New York, and am director of laboratories of the Department of Water Supply of that district; I am also a member of the Pollution Committee of the Merchants' Association.

The similarity between the conditions in Boston harbor and those in New York harbor have been pointed out, but I wish to bring out some very essential points of difference between the Boston
163 harbor conditions and those in New York.

The sewage of Boston harbor is screened, passed through four large settling tanks, through and under a large settling tunnel, in all of which places considerable sediment is removed. It is

then allowed to flow out at some depth to beyond Moon Island, and as it flows out, it is deposited only one hour after the ebb of the tide; in other words, they are very careful not to allow the sewage to flow during all periods, as it has been found that it would flow back into Boston harbor and cause serious detriment there.

The Chairman: What sewer is that?

Dr. Jackson: The Moon Island sewers in Boston. The sewage of the Boston sewers——

The Chairman: Is that the one that enters in just below Deer Island?

Dr. Jackson: No; the Deer Island and Nut Island are smaller sewers and of more recent construction. I am speaking of the main Boston construction, which is that of Moon Island, in the outer harbor.

Now, it was supposed that when the sewage was discharged there, it would become intimately mixed in the waters of Boston harbor. As a matter of fact, as it discharges below the surface, it immediately boils up and spreads out over the surface, and that is because of the difference in the specific gravity of the sewage due to a difference—some ten or twenty degrees, in temperature and due to the difference in weight between fresh and salt water, which immediately brings that sewage to the surface just as if it was in a funnel, and
164 if discharged at a lower point the diffusion is very slight causing it to float out over the surface.

The last time I was at Moon Island, and I went there particularly to see the beginning of the discharge and to watch it during the entire period, and I know that there was practically no diffusion. Of course, the discharge there was not so deep as it is intended here, but the point is that the discharge there—from different points—it was put below the surface, and it immediately rises up, boils up from six inches to a foot and spreads out over the territory there for several square miles, in fact over the distance of the water, that is, as far as you can see, all the way over to what is called Long Island.

Now, all the examinations that have been made of that water show that the sewage is all practically within six inches to a foot of the surface; in other words, it does not intimately mix up with the salt water, and on account of those conditions—the difference in specific gravity, and coming to the surface as it does, it is spread out on account of that same difference in the water—fresh and salt. Then, of course, after spreading out over this broad territory, it becomes more or less quiescent, and then deposition takes place.

Now there is another essential difference in Boston harbor as the rise of the tide there is from twelve to fourteen feet at that point whereas in New York harbor it is from four to six feet only and that makes a very marked difference in the velocity which
165 would carry away these materials or depositions. The fact that the sewage here in this application, in New York harbor is to be deposited forty feet below the surface is not a very essential feature to my mind. I believe that that sewage, the moment it leaves the outfall, will rise suddenly to the surface, with considerable velocity, due to the quantity and due to the difference in the

rate of flow here and will, during the ebb tide, flow all the way between Robbins Reef, out through the Narrows and cause a disagreeable odor and unsightly appearance over that territory and during the flood tide will undoubtedly flow up around on both sides of Manhattan Island. There is no reason why this should not take place. The sewage which is deposited in the New York bay at the present time does exactly this same thing in a smaller way—on a smaller scale, for the reason that it is deposited in small outlets all the way 'round Manhattan Island, all the way around Brooklyn over a territory with a water line of perhaps thirty miles, and yet even with that distribution the sewage in New York harbor is practically all at the surface, all of the recent sewage and a chemical examination, and a bacteriological experiment and experiments which have been made and I have made most of them myself, show that this sewage is at the surface—all of the recent sewage—is at the surface of the water and down only a very slight distance is a very marked addition in the purity of the water—a marked difference in its purity.

Now, the first point is that the sewage will be spread out
166 over a very broad area of the harbor.

The next point is that the materials in suspension will be gradually deposited at points where the velocity has been slowed up.

The Merchants' Association feel that there is no valid reason why the sewage of the Passaic Valley should not be purified before it enters the waters of New York harbor.

Col. Knight: One or two questions, please:

Col. Roessler: I would like to ask this question: You refer to the rising of the sewage in Boston harbor due to the difference in temperature; is it not true that the temperature of the water in Boston harbor is quite a bit lower than the temperature of the water in New York harbor, and that therefore the difference between the temperature of the sewage and the water in which it is placed in Boston harbor is greater than the norm would be with reference to the Passaic Valley sewage and the waters of New York harbor?

Dr. Jackson: I did not say that there will be no difference—I do not get your point——

Col. Roessler: The temperature of the water is much lower up there——

Dr. Jackson: It is much lower there——

Col. Roessler: The temperature of the water up there is much lower than the temperature of the water in New York harbor is it not?

Dr. Jackson: Yes. In Boston harbor I was informed that the temperature which had been taken, the difference in temper-
167 ature between the sewage and the water was about twenty degrees; I am not sure of those figures, but that is what I was told there. I understand that the difference here in New York harbor would be between ten and twenty degrees.

Col. Roessler: Is that in Summer? That difference of twenty degre-s between the temperatures of the sewage and the water in Bos-

ton harbor, you know that the water up there is considerably colder than it is here.

Dr. Jackson: That is a sort of average. My statement was that it is about ten to twenty degrees here.

Col. Roessler: In New York harbor?

Dr. Jackson: Yes, sir; I think it is a fair statement, from my experience.

Col. Knight: You referred to the velocity of the flow of the tide at the sewer outlet being greater in Boston harbor than it is in New York harbor; do you know actually what that velocity of flow is?

Dr. Jackson: No, sir; I only know that the difference in the tides is very considerable and naturally the velocity of the flow must be greater. I do not know the actual velocity.

There was one essential point I would like to bring out, which I forgot. In the Summer time, in New York harbor—in Boston harbor, I mean, there is a deposit of from two to eight feet of sewage sludge between Moon Island and Long Island. Every Summer. This sludge backs up on the right of the Boston harbor and on the right of the outlet so that there are considerable flats exposed,
168 of sewage sludge, during the Summer time. The engineer who put the water pipe from Moon Island to supply the water for Long Island had to cut through this sludge to get his pipe through and he cut through from two to eight feet of mud, sewage mud which he assured me had certainly the essential odor of sewage mud at that point, from two to eight feet depending on the contour, of course, eight feet in the deeper portions, as the sludge settles into those parts.

Now, the reason that there is not a very heavy deposit in Boston harbor is because, during the Winter time this sludge, which is deposited in large amounts over several miles of territory is broken up by the very heavy sea at that point during the Winter and is redistributed, so that it is not apparent there. Much of it naturally goes out to sea; some of it is distributed over the near portion of the harbor; at all events, if it were not for the Winter storms which create a very heavy and high seas which they have at that point the sludge there now would be much above the present surface of the water at high tide.

And I want to point out a strange thing, and it is that the conditions which occur in the Boston harbor during the Summer time, are the same conditions which occur in New York harbor throughout the year, and that that deposition which takes place in Boston during the Summer time, of this sewage sludge, is going to take place constantly in New York harbor, instead of intermittently as in Boston harbor.

The Chairman: You mean to say that New York would
169 not get the benefit of the very heavy Winter storms they get in Boston harbor and which serve to disperse this deposit as you have stated?

Dr. Jackson: In New York harbor they have a double protection against heavy storms; they have the outer bay and the quiet waters of the harbor, which are unusually quiet for a harbor.

Col. Knight: How far from the mouth of this sewer is the effect of that Boston sewage noted; how many miles from the mouth of the sewer, where it is discharged into the Bay?

Dr. Jackson: There is no appparent effect — inches from the mouth of the discharge sewer, which it has been in any way able to measure; there are certain deposits at varying distances—fully a half mile inland towards Boston.

Col. Knight: Well, how far will the tidal currents carry that sewage?

Dr. Jackson: When the sewage is discharged, there is a sharp line on the North of the discharge, this is apparent and defined, and from the temperature of the water which indicates where the sewage is.

Col. Knight: How far does the tidal current carry the sewage so discharged?

Dr. Jackson: It does not flow beyond that point only a matter of a few hundred feet.

Col. Knight: A few hundred feet?

Dr. Jackson: That sharp line, which you can see extending off for a couple of miles shows the battle between the sewage,
170 which would flow towards the harbor, and the very strong current which occurs during the time of the outfall, at the other edge of the outfall.

Col. Knight: But that discharge is made on the ebb?

Dr. Jackson: Always, and one hour after the beginning of it.

Col. Knight: Well, then, the following flood then does not carry it beyond this line of demarcation you have spoken of?

Dr. Jackson: That is a matter which is very difficult to judge.

Col. Knight: But you say this line is apparent and sharply defined, and I asked you how far the tidal current carried——

Dr. Jackson (interrupting): This line is surface water——

Col. Knight: The line you speak of is on the surface of the water and you are speaking of the mass of material coming at once to the surface of the water, so we are treating of what is floating on the surface; you find the line of demarcation about a half mile inland; do you ever find it further inland?

Dr. Jackson: No.

Col. Knight: Then the recurring current of the tide does not work this sewage up into Boston harbor?

Dr. Jackson: I spoke of the deposit——

171 Col. Knight: I am speaking of the surface indication——

Dr. Jackson: That I am not familiar with——

Col. Ruffner: How many hours did you watch this?

Dr. Jackson: About two hours.

Col. Ruffner: About the time of discharge?

Dr. Jackson: Yes,—just before the discharge until the end of it and kept track of the facts; of course, there is a discharge of two hours, starting one hour after the ebb tide stars.

Col. Knight: Well, then, how do you reach your conclusion, as you have stated it, that if this flood does not move this material inland in Boston harbor so far as the surface indications are concerned,

that the flood tide will move it from Robbins Reef up around on both sides of New York harbor?

Dr. Jackson: As I understand this proposition, that discharge is not on the ebb tide, but during the entire period, and, of course, the conditions under those circumstances would be utterly different; that is, during the flood tide, the disagreeable part of the material, and the odoriferous part of the material would be carried up the harbor and around the City, and, during the ebb tide, would be carried out of the harbor.

Col. Knight: But, from the Boston statement, I infer, then, that if it all goes out of the harbor on the ebb tide, as you say, the recurring flood tide does not bring it back.

Dr. Jackson: I think not to any great extent—I think that
172 is account- for by the fact that it is practically open sea there—And the islands——

Col. Knight: Then this material, down here, discharged on the current of the flood tide, could not go farther inland than one flood would bring it?

Dr. Jackson: No; I think not.

Col. Knight: How far—Do you know anything about the tidal velocity here on the flood tide?

Dr. Jackson: I have not been personally connected with that work—I know of it through other sources—I know that the floats charted by the Metropolitan Sewerage Commission would easily go beyond the City——

Col. Knight: What velocity do you get from that?

Dr. Jackson: That I am not familiar with; I do not know the velocity; I know the condition that the floats put in at Robbins Reef will go up just beyond the Narrows if put in at the beginning of the ebb——

Col. Knight: Will the recurring flood tide bring that back as far as Robbins Reef?

Dr. Jackson: Most of them were deposited on the North shore of the island——

Col. Knight: I know, but those that were not deposited on the North shore, of course, would they come back as far as Robbins Reef?

Dr. Jackson: Of course, they meet the Hudson River effect: there would be an oscillation in the harbor and always would ultimately pass out further——

173 Col. Knight: In other words, then, the material could not possibly go farther North—could not go upstream farther than one flood tide would bring it?

Dr. Jackson: No; of course there is a difference in high floods——

Col. Knight: I am speaking of the average conditions?

Dr. Jackson: That would be the case.

Col. Knight: Then how far is Robbins Reef below the Battery?

Dr. Jackson: I do not know the exact distance.

Col. Knight: Then, if you do not know the exact distance, and do not know the rate of flow of the current, how can you predicate that this stuff will come up here on both sides of New York?

Dr. Jackson: For the reason that the floats put in at the Battery will go down beyond Robbins Reef and back——

Col. Knight: But would they come back as far as they went down?

Dr. Jackson: Nearly as far.

Col. Knight: Well, then, you still do not say how you reach your conclusion,—if you do not know the rate of flow, the velocity, or the distance, I do not know how you can assert that that material will go that far——

Dr. Jackson: Well, the material being on the surface of the water will very likely go about the same distance as the floats will go, and while the velocity of these currents in New York harbor have
174 not been very well worked out, it is fair to assume that where the floats will go the surface material will go.

Col. Knight: But you do not know where the floats will go. You only say that some put in off Robbins Reef go down to the Narrows and come back nearly as far or pretty nearly as far, but you do not know anything about floats from Robbins Reef coming up on both sides and around the City of New York——

Dr. Jackson: I think that is a matter that Professor Landreth, who follows me, may be able to answer.

Col. Knight: I simply want to get a foundation for your remarks that this material will be carried up on both sides of New York, on the Hudson river side and in the East River on that side of the City——

Dr. Jackson: The matter of the velocities of tides and those matters are not in my province.

Col. Knight: Then your statement about the material coming up on both sides of the City is not based on actual knowledge?

Dr. Jackson: It is based on what has been done in connection with the pollution of the harbor by the New York Bay Pollution Commission and by the Metropolitan Sewerage Commission, and upon the results of the float work as seen and as charted by those bodies?

Col. Knight: But the report—You have seen the special report of the Passaic Valley Sewerage Commission?

Dr. Jackson: I am not familiar with it.

175 Col. Knight: Then you are not familiar with all its statements concerning the tides and the floats in that report?

Dr. Jackson: No, sir.

Col. Ruffner: I understand you were appearing as an expert on these matters?

Dr. Jackson: I am a sanitary expert and an expert on sanitary chemistry.

Col. Ruffner: You are an expert merely on the chemical side of the question?

Dr. Jackson: General sanitation.

Col. Ruffner: Then your assertions as to where this material is likely to go is not expert testimony?

Dr. Jackson: I draw my conclusions, my inferences from what I have seen——

Col. Ruffner: Just what you have seen of these charts of the lots?

Dr. Jackson: I have spent probably as much time on New York harbor, studying these matters as any other one man; I have collected the matters of research in pamphlets and they have been sent around to the various interests and engineers——

Col. Ruffner: You are not an expert on the flow of the tides and tidal action?

Dr. Jackson: Not on the flow of the tides.

Col. Knight: Now, then, that takes out your statement that this material would come up around on both sides of New York
176 City. Now, then, you stated that this material when discharged from these pipes will rise at once to the surface, that because of the different density, specific gravity and temperature will bring it suddenly to the surface and that it will hang there and not be readily diffused——

Dr. Jackson: There should be some diffusion, of course,—there is same in Boston harbor——

Col. Knight: That is, by diffusion, you say; but by specific gravity, you say the effluent rises as a rule to the surface,—then how do you get the deposit in the bottom of the channel in the lower bay here?

Dr. Jackson: That is from different, heavy, material.

Col. Knight: But we have no heavy material,—you have described the amount of sedimentation—you have said that it goes through several settling tanks and through a long tunnel, and that then, as a result of lesser specific gravity, it rises at once to the surface; then where is the material going to come from that is going to fill up and diminish the navigable portion of the harbor?

Dr. Jackson: It is eventually deposited. As the result of the temperature, the suspended matter rises on being discharged, at once to the surface, and floats out over the surface, and then slowly deposits.

Col. Knight: What causes it to acquire the extra specific gravity, then, to drop it to the bottom of the bay?

Dr. Jackson: There is an action of salt water on sewage material which is productive of the condition which, I think Dr.
177 Soper brought out yesterday,—there is a precipitating action on the material, the suspended matter in solution——

Col. Knight: What was brought out yesterday was a photograph showing vials of different colors,—but no determination as to the amount of sedimentation——

Dr. Jackson: And we know that in salt water the sedimentation is greater than in fresh water, and a great many experiments have been made to show that——

Col. Knight: But now, what proportion, say, of a cubic foot of sewage comes out and is kept afloat by this specific gravity that you referred to as being true out at Boston, what portion of a cubic foot of sewage, or of the heavy constituents of sewage thus in suspension as you have stated, just what part of that will ultimately be made

heavier than it was when it came out of the sewer so as to form the deposit——

Dr. Jackson: You mean the matter in suspension?

Col. Knight: This matter that changes somewhere by contact with sea water, changes its specific gravity and drops?

Dr. Jackson: The sewage precipitates in time, it changes its specific gravity in solution and is then deposited. It is, as you might say, when the matter is surrendered, the residual deposit, which is determined by the salt in the water.

Col. Knight: Have you ever determined the parts in a thousand that that heavy matter that is deposited or precip-
178 itated form; have you ever determined how many parts in a thousand of ordinary sewage?

Dr. Jackson: That, of course, differs very widely with different sewages.

Col. Knight: Have you determined it for any of them?

Dr. Jackson: The chief pollution in suspension would naturally precipitate in course of time—only a question of time.

Col. Knight: Specify it; its volume; does it vary? Can you tell me between what limits it varies? Don't you see, the important feature is, here, if there is going to be an interference with navigation due to shoaling of the waters due to deposits, it is important to establish the rate of that deposit. Now, if you can give anything definite bearing on that, it is important to present it. You appear now without any special information as to the tides or currents, but you do appear here as a chemist: Now, can you tell us, from any analysis or from your observations of any sewage, how much sewage, solid matter, in parts to the thousand, will be discharged after this process that you spoke of, at Boston, has been completed?

Dr. Jackson: I should say, anywhere from two hundred to one thousand parts in a million; that is, one thousand parts in a million would be one part in a thousand.

Col. Knight: That is based upon your own knowledge?
179 Dr. Jackson: That is a general statement, based upon examinations of a great many sewages.

Col. Knight: Based upon your own examination?

Dr. Jackson: Yes, sir. I have had a great many years' experience and have made a very considerable study of the sewages of different cities——

Col. Knight: We are not asking that. From the fact of your appearing here as a witness on behalf of the opponents of this application, we take it for granted that you are present as an expert. Now, as the result of your own work, can you tell us anything as to that proportion? You say, from two hundred to one thousand parts in a million: Is that based on actual examination you have made?

Dr. Jackson: It is based on actual examinations I have made at Boston. The one part in a thousand is probably the amount that would occur at this point.

Col. Knight: You can say then, that from two hundred to one thousand parts in a million will be discharged, or may be expected to be discharged in Boston by this system after all of this process is

completed, or is this the part you find in sewage before it is subjected to any treatment whatever?

Dr. Jackson: That is the proportion I find in the sewage before treatment.

Col. Knight: Now, how much of this is removed by screening and sedimentation in the Boston treatment?

Dr. Jackson: In the Boston treatment, it is somewhere about one-half that is removed. But those figures of two hundred parts to the million will not apply to Boston.

180 Col. Knight: Well, we will take one in a thousand as the base. You say you think one-half of that is removed? Have you any means of determining—have you any measure—or have you ever measured it? Or, have you determined it by the amount of material you find in deposit in the plant as a result of the process of purification?

Dr. Jackson: I was assuming those figures from the analyses of the difference between the two; between that which goes over to Moon Island and that which flows out,—that which goes to the pumps.

Col. Knight: Then you have analyzed this discharge?

Dr. Jackson: I have not analyzed it myself.

Col. Knight: But you know——

Dr. Jackson: I have seen analyses, and I have also taken samples which I have been examining recently. The difference in that sewage over in Boston harbor as between ordinary sewages is very considerable. I would not think that that sewage would be a representative one or that it would represent what we would get here, for the reason that my examinations there of the compressibility of that sewage, which I have been making recently, have had very surprising results,—I have found that the compressibility there is as one to ten, that is, it requires the addition of ten parts of dilution to one part of sewage to prevent a disagreeable odor, whereas in ordinary sewages it will run as high as one to twenty or even one to thirty, so that that sewage is hardly representative of this.

181 Col. Knight: But, in fact, it is important. That brings us down to five hundred parts out of a million,—five hundred parts of material that can be positively deposited after discharge, out of a million that go to the works. That is, you remove one-half of one thousand, which leaves five hundred parts to the million to be discharged.

Dr. Jackson: In Boston——

Col. Knight: In Boston,—I am still speaking about Boston—what is the allowance of sewage per capita; of what does that sewage consist before treated; is it a separate system, or not?

Dr. Jackson: It is separate there for Moon Island, yes, sir——

Col. Knight: But does it take the sewage,—does it take all the sewage from Boston, or if, in Boston, the storm sewage separated from this? I want to know what goes into this plant?

Dr. Jackson: The Metropolitan Sewerage——

Col. Knight: Now you said—I am talking about the Moon Island sewer,—is that a separate system?

Dr. Jackson: Yes, sir; it is a separate system.

Col. Knight: In other words, nothing goes into that sewer, but the ordinary house sewage and factory waste?

Dr. Jackson: The ordinary sewage and waste; most of the storm water is cut out.

Col. Knight: What is the allowance,—the amount of sewage per head in Boston?

Dr. Jackson: I think about one hundred gallons.

182 Col. Knight: One hundred gallons?

Dr. Jackson: I think it is one hundred gallons per day.

Col. Knight: Then this is practically the same—or, is there any trade waste in that?

Dr. Jackson: I should assume there would be some.

Col. Knight: Do you think it is practically the same amount per head as is considered there in the Passaic Valley proposition?

Dr. Jackson: Yes. The difference in what is deposited, however, there would be a difference,—the large settling tanks and in the long tunnel in which they also settle out their material and remove it before they deposit it into the harbor.

Col. Knight: You said, remove it from that long tunnel; is that done?

Dr. Jackson: I understand it is shut down—shut off and the material is taken out occasionally.

Col. Knight: Taken out, how?

Dr. Jackson: Either pumped or shoveled out.

Col. Knight: Then it must be agitated, or mixed up?

Dr. Jackson: I think so.

Col. Knight: It would be best to do that on this tunnel here, would it not?

Dr. Jackson: It would be best to make such an arrangement.

183 Col. Knight: Now, another matter, with respect to that sewage coming up on both sides of New York harbor, you know nothing about the preponderance of the ebb discharge of the East River over the flood?

Dr. Jackson: During the flood tide the Hudson River flows down into the sea, and then flows out again.

Col. Knight: How about the East River?

Dr. Jackson: The East River flows eastwardly during that time.

Col. Knight: During the flood?

Dr. Jackson: Yes.

Col. Knight: Well, now then, during the ebb the East River goes down this (indicating) way; does it run about the same quantity as the Hudson river? Are the quantities—the contents of the tide in the rivers equal?

Dr. Jackson: Probably not; I do not know that that has ever been determined.

Col. Knight: Oh, yes; it has decidedly been determined. There are four hundred million cubic feet preponderance from the East River on the ebb tide over the Hudson river: Have you any condition like that in Boston?

Dr. Jackson: The conditions in Boston are that there are a number of small islands out above this point.

Col. Knight: I know, but have you anything like that tidal discharge, any single preponderant of four hundred million cubic feet? Have you anything corresponding to that as a method of dilution in Boston?

184 Dr. Jackson: I do not think there is any great difference between the discharge through the East River and the discharge through these various islands in different directions in Boston harbor; the action of the tide is about the same.

Col. Knight: I think the hydrographic conditions are entirely different there.

Do you know anything about—since you say you have been studying this sewage here—do you know anything about the sewage down at Gowanus Canal? And Newtown Creek?

Dr. Jackson: I do; I have made a great many examinations of it.

Col. Knight: Well, how would you compare the condition of the sewage at the head of that Creek and at the mouth of it?

Dr. Jackson: At the head of Gowanus Canal it is a very strong quality of sewage——

Col. Knight: Yes?

Dr. Jackson: As it goes further down it is diluted by factory waste; there is a great deal of precipitation from those wastes, and at the outlet it is somewhat more diluted than the ordinary sewage, but much worse at the surface than below—through the Oak Run——

Col. Knight: How would it compare at the mouth with the Boston sewage,—just at the mouth,—not at the top of the Canal,—but the sewage after it is treated by those works, but as it goes into those works?

185 Dr. Jackson: In appearance, it is very much darker—the comparison is not a very good one for the reason that we have factory waste there, which has a precipitating action in the Canal itself, and the conditions are entirely different, but a comparison——

Col. Knight: Well, you have the standards by which you compare sewage—whether sewage is harmless or not,—you have the comparisons to determine the degree of contamination in the water, haven't you?

Dr. Jackson: Yes; I should say that our chief comparative requirements are provided for, and the prospect of precipitation, the amount of water necessary add to that sewage to keep it from giving off a strong odor on incubation.

Col. Knight: The amount of water to keep it from giving off a strong odor,—then, taking that sewage at Boston, do you know what amount of water would keep that from being offensive?

Dr. Jackson: About one to ten, I should say, or less.

Col. Knight: Then, you would want to dilute it about one to ten?

Dr. Jackson: Yes. Ordinary sewage is diluted about one to twenty.

Col. Knight: Ordinary sewage? This Boston sewage is only half, as compared with ordinary sewage? Boston sewage is only half as strong, do you mean to say?

Dr. Jackson: That particular sewage is weaker in precipitates.

186 Col. Knight: This sewage which comes out of the Boston sewer, treated at Moon Island, you rate that as only half as strong as the ordinary sewage?

Dr. Jackson: Yes. I do not know that—Yes, I think I can safely say that. I have made precipitation tests on it which gave that result, in many tests, too.

Col. Knight: Has any test been made of that water at Gowanus?

Dr. Jackson: Yes; the proportion is as one to thirty there; it is stronger there.

Col. Knight: One to thirty at the mouth or the head?

Dr. Jackson: At the middle of it. I should say one to twenty at the mouth.

Col. Knight: Then, taking it as one to thirty, what do you mean by that, in ordinary English?

Dr. Jackson: The amount of material which is there, would have a decomposing action, would be strong enough, if thirty parts of water is added to it, and it is allowed to settle, and it is allowed to stand with the sediment in it, it will develop a strong odor, and lose all of its oxygen, all of the air which is in solution,—that is the test of the organic strength of it.

Col. Knight: Then, it is still harmful after that dilution of thirty to one?

Dr. Jackson: At that point it will just putresce, beyond that point it will not.

Col. Knight: Then thirty-one to one would make it safe,

187 and remove the offensive character?

Dr. Jackson: I do not know as to safe; but it would remove the offensive character.

Col. Knight: Well, then, eleven to one would remove the offensive character at Boston?

Dr. Jackson: It would, if diluted with the water, but if it is floating out over the surface, it does not have the same effect. We know very well that the offensive character is not removed on the surface of Boston harbor, for the reason that you can smell it, a very strong stench, over a very wide area: That is just the point; that it is not diluted.

Col. Knight: Well, what measures have been taken down at Gowanus creek or Gowanus channel to clarify or purify that?

Dr. Jackson: We are installing a pumping station to flush out the channel.

Col. Knight: What is the discharge of the creek?

Dr. Jackson: Those figures,—the amount of the discharge, are not within my province.

Col. Knight: You do not know, then, of any relation between the

discharge of the creek and the capacity of the discharge pumps in the pumping station?

Dr. Jackson: No.

Col. Knight: You do not know the proportion of water that is to be furnished to dilute that?

Dr. Jackson: No, sir: The action is one of flushing, as I understand it. They are to remove all the material, I understand, flush it out into the harbor.

Just one other point, if I may: You spoke of that strong discharge of the East River, into New York Harbor. That is true, in volume, but it does not have the effect that would naturally be supposed, for the reason that a very large portion of it is an under-run, rather than at the surface, and we have got to consider these matters from the surface conditions, that is, raw sewage from surface conditions rather than under-run, and the same is true of the under-run at the Narrows; the solution is not the same as to the volume of the under-run, it is the volume of the surface——

Col. Knight: You are speaking of an under-run: Do you know the extent of the under-run?

Dr. Jackson: I know it is a strong under-run.

Col. Knight: Do you know how it affects the surface?

Dr. Jackson: I know that the under-run is of comparatively clear water, and that the sewage is at the top,—on the surface——

Col. Knight: Do you know how far the under-run tide water goes in the Hudson river?

Dr. Jackson: I know it goes a long distance up the river.

Col. Knight: Do you know how deep the under-run is in the East River?

Dr. Jackson: No, sir.

Col. Knight: Then, how can you say its condition?

Dr. Jackson: From the conditions apparent in the appearance and in the position of the sewage itself.

Col. Knight: If the waters of the East River have got to go over a shoal—as it does—varying in depth from thirteen and a half to eighteen feet, how does that bear out your statement as to the under-run?

Dr. Jackson: I have made an examination by solution, for instance, of the amount of chlorine in the water of the under-run, and the difference from the surface is very material; if you go down just below the surface, it is one-half that at the surface,—and you get a considerable difference at varying depths, in the salts, and we have made a cross-section of the chlorine in the Hudson river, and we have found the fresh water and sewage practically all at the top, and that the salt water flows out underneath.

Col. Knight: Then, this precipitation which you say takes place of this matter in suspension because of the specific gravity,—that you believe is all on the surface, in the fresh water?

Dr. Jackson: Very largely at the top.

Col. Knight: Then you say something about this matter going back into the salt water, and being precipitated by the salt water, insolution, with an increase in the specific gravity?

Dr. Jackson: The fresh water is at the very top where the sewage is discharged into the salt water at the outfall, it boils right
190 up to the surface, and above the surface, then gradually becomes quiescent, and the part which precipitates comes in contact with the salt water?

Col. Knight: When you spoke of the volume, as to so many parts in a million, the dilution was to be all by water?

Dr. Jackson: All by water.

Mr. Child: May I have the privilege of presenting, as part of the case of the petitioners, certain extracts which I have caused to be made from the United States Coast Survey Reports?

The Chairman: Do you wish it to form part of the record?

Mr. Child: If I may.

The Chairman: That will be done.

(The following was submitted):

"Extracts from United States Coast Survey Reports:

In our opinion the conservation of ample channel ways at Sandy Hook is due in some measure to the tidal circulation which the Hell Gate entrance permits. This circulation is the life-blood of the harbor, cleansing the channels from the silts of its rivers, as well as from the sewerage of its cities, and even sweeping the sands from its grand avenue to the ocean.

New York Harbor is visited by two derivations from the tide wave of the ocean, one of which approaches by way of Long Island Sound, the other by way of Sandy Hook entrance. These two tides
191 meet and cross or over-lap each other at Hell Gate; and since they differ from each other in times and heights they cause contrasts of water elevations between the Sound and the Harbor, which call into existence the violent currents that traverse the East River.

Extract from U. S. Coast Survey 1867, pp. 158 and 159.

Two tide waves visit New York Harbor, meeting and overlapping at Hell Gate.

(2) Near the meeting point of these two tides the observed heights and times of the compound tide are intermediate.

(3) The currents of Hell Gate are called into existence by the variations in the relative heights of the Sound and Harbor; their epochs have no direct relations with those of the local tide, or its components, and their velocities do not depend upon the local rates of rise or fall of tide.

(4) The current flowing westward through Hell Gate occupies a greater section than that flowing to the eastward, because the former prevails during higher stages of the local tide than the latter.

U. S. Coast Survey, 1867, p. 161.

Although the tidal currents of New York, especially in the East River, appear to move to and fro with ebb and flood in monotonous repetition, like the swing of the pendulum, there is a net gain, under ordinary conditions of river discharge to the westward, i. e., a perma-

nent transfer of water from the Sound through the Harbor
192 and out into the ocean over Sandy Hook Bar. This state-
ment, if true, involves so many consequences affecting the condition of the Harbor (its navigation and its improvement) that I have put it in the form of a proposition to be demonstrated, first, from the most general relations of the Sound and Harbor tides, as oscillations of the sea "interfering" at Hell Gate; and second, from a strictly inductive study of gaugings made by different observers at different dates. I shall show that it ought to be theoretically, and then show that it is true practically.

U. S. Coast Survey, 1886, Page 409.

The peculiar quality of the East River current as compared with the free tidal current is that the former is a gravity stream, namely it is water running down a slope, as in a fresh water river.

U. S. Coast Survey, 1886, Page 410.

Although the Hudson, and other rivers flow into New York Harbor, and slightly raise its level, the conditions illustrated in our diagram are very nearly realized in the Seasons when the fresh water discharges at a minimum. One of these Seasons is the Autumn; the other is mid-winter when the land waters are ice bound. At such times the greater velocity being westward, and the greater depth of water being that of the westerly flow, there is, as a net result, a circulation of sea water through the Harbor from the Sound to the Ocean. In Mid-Winter this circulation renewing the water before it can get chilled, and lowering the freezing point by mixing sea
water with the river discharge, serves to keep the port open
193 to commerce. One may form some estimate of the value of
the four degrees difference of the freezing points between sea and river waters when it is remembered that in severe Winters Halifax, Portland and Boston have not closed before Philadelphia or even Baltimore.

The indirect value of this influx from the Sound during the dry Season lies in the partial supply of the underrun of sea water which occurs when the head of the river is insufficient to counterbalance the greater density of the sea water. We do not find this under-run (or preponderance of inflow) at higher levels than the deepest channel beds of the bar except on rare occasions; but one may easily see that the withdrawal of the influx from the Sound would cause the bar to rise and work inward. The fresh waters that enter from the Hudson and other streams play an insignificant part in the physics of the Harbor; but the circulation of the sea by way of the East River, although small in quantity, is the element which determines the superiority of New York Harbor over nearly all the sand barred inlets of the World. It is this circulation which keeps the port open in Winter and sweeps the sand from its threshhold.

U. S. Coast Survey, 1886, page 411.

The whole amount of water which flows into the New York Harbor in the course of each tide through the East River is sufficient of

itself to raise the water of the Harbor by one foot and one tenth.

The ebb commences two hours before the turn of the tide in
194 the East River and during these two hours the flow is toward the East River instead of from it. Next the amount of flow into the Harbor must be proportionately diminished and reduced to nine tenths (.9) of a foot. Now the Harbor at high tide has four and two tenths (4.2) more of water in it than at low tide, which runs out during the ebb, together with the flow from the Hudson, which is about the same as that of East River. The whole of the flow then through the Narrows which is independent of East River, corresponds to five and three tenths (5.3) feet in elevation of the surface of the Harbor, and this is the amount which would run if East River were to be cut off. The additional nine tenths (.9) of a foot which arises from East River gives a total of six and two tenths (6.2) feet as representing the flow through the Narrows and over the Bar. If the East River were cut off, the corresponding decrease in the flow of water would involve a proportionate decrease in the water-space over the bar or a reduction of the depth of water upon the bar of about three feet and a half. Such is the measure of the importance of East River to the preservation of the entrance to New York Harbor. The loss of this river would involve a fatal injury to the Harbor and any obstruction to its flow or reduction of its capacity must be proportionately injurious.

U. S. Coast Survey, 1871, Page 110.

Computations made upon the observations at different depths in 1858 gave for the discharge of the Hudson, at the close of the set

Season (1st June), 6,038,000,000 of cubic feet, and at the
195 close of the dry season (September) 3,360,000,000. Our more extended observation of 1872 (October) give nearly equal in flow and outflows amounting to 4,511,000,000, which is about the mean of the two gaugings of 1858. Now this added to the ebb volume of the East River, which was 4,383,000,000, gives 8,894,000,000. If to this we add the Harbor tidal prism 17,862,000,000, (which includes Newark and Raritan Bays, and the Kills), we have 26,756,000,000 of cubic feet. The gauging across the mouth of the Harbor from Sandy Hook to Coney Island gave, from observations of 1858, an outflow of 27,663,000,000 of cubic feet, which is only about two and one half per cent. more than the preceding computation. * * * Without claiming that all the water which comes in through the East River goes out over the Bar, and aids in the scour of its channel, I think this computation authorizes us to regard the East River stream as too important to be treated lightly.

I must add one general statement concerning a harbor with two or more outlets. It does not follow even when such a Harbor is visited by only one tide that there is a disadvantage in having more than one pathway to the sea, on the contrary a majority of the first class harbors of the world have several. Among sands it is not wholly upon the strength of the current that effective scour depends, but upon the power of these to dispose of the material advantageously. Equal and opposite tidal currents, however strong, cannot remove

the bars of our southern inlets, because in the short period of
196 six hours the very slow dune-like movement of the sand has not carried it beyond the influence of the adverse stream with which it works back to its old place; but where the ebb and flood are unequal, the material is swept entirely away from the mouth of the harbor. Now, with harbors of two outlets, it often happens (and I speak here with plenty of observed data at my command) that one channel is more favorably situated for discharge than the other, so that, in effect, there is a circulation in at one door and out at the other.

U. S. Coast Survey, 1871, Page 118-119."

Mr. Dean: Captain Parsons, who spoke yesterday, and who was formerly president of the Maritime Exchange, would like to add a little further to what he said.

Captain Parsons: Mr. Chairman and Members of the Board, in my desire to be explicit, and not occupy valuable time, I omitted some things that it was desired I should refer to. One of those was the effect of the sewage upon the metal on the bottoms of wood vessels loading in localities where the water is perceptibly polluted, say, for instance, that at Newtown Creek. Vessels going into Newtown Creek, and loading with oil, have frequently—with a new coat of metal, have frequently been obliged to re-metal their vessels at their destination on account of the metal having been perforated by the chemical action of this polluted water. So much so has this prevailed and to such an extent that frequently merchants in chartering freight vessels to load here have excepted Newtown Creek
197 from the privileges of the parties making the charter as to the parts of the City where vessels might be loaded.

Another was that, of the amount of expense incurred in dredging out the piers and wharves, caused by the deposits, made annually, in 1905, I must speak from memory because I have mislaid the document which I had secured, in 1905, over $800,000.00 was expended in dredging the slips and wharves just on account of this deposit made from the matter contained in the water where there was no action of tides, and this was very largely augmented by amounts expended by private individuals and for private wharves and piers, which must be done by themselves, in order to enable them to receive vessels drawing a reasonable draught of water.

The question of carrying the sewage directly to sea, which has been a prevalent opinion, until this matter was discussed a few years ago, has been very conclusively proved to be an error from the fact that the current—for instance, objects spread,—started from the Battery, even on the first of the ebb tide, will not reach the sea, but when in the lower bay, down within four or five or six miles of Sandy Hook, will meet the flood tide and be deflected into the bays, that which is further up, into the lower or Gravesend Bay, and that in the lower bay takes a circuit and finally comes back up through the Narrows again into the lower Bay.

I referred yesterday to the filling up of channels across
198 which the tide flowed rather than through them directly. This, of course, occurs where the channels are shallow, where

they are used mostly by our smaller class of vessels and so largely has this prevailed, that some of the anchorages used by this small class of vessels, such as the bay into which the Gowanus canal enters, the charter has found have been shoaled to such an extent as to almost practically destroy their usefulness to owners of vessels who have been formerly in the habit of anchoring in those places.

I was asked in reference to the apparent quantity of sewage in New York Bay and in the lower Bay, out where it could be seen. I desire to say that in my personal connection as a navigator in this Bay and in this Harbor, that it is not much in evidence in the stress of the current. That part of the harbor and bay which is used by the larger vessels it does not appear except the lighter material which floats on the surface. I have seen a dead horse make excursions up and down the river until he finally decided to locate himself somewhere along the South shore of Raritan Bay, but, ordinarily, the sewage is not much in evidence: but it is in the water and deposits itself along the shores. I have noticed upon a comparatively flat or sloping beach that the largest amount of the deposit was at the point of high water, but that it prevailed all the way down this sloping beach until it reached the flat surface, diminishing in quantity, usually, that there was more of it on the surface, but that it was
199 continually settling wherever the water was not in action.

In making the statements which I have made yesterday and to-day, I make them, not so much as an expert as from the viewpoint of a practical observer, and coming in contact with these interests to which I have alluded. The questions to which I referred yesterday, of its affecting the paint of vessels, that also shows very plainly over the painted surface as there will be a well-defined waterline derived from contact with the surface of the liquid around the vessel the paint of which is light-colored enough to permit it to be shown or which can be readily discovered even in black paint. I believe that is all.

Col. Ruffner: I want to ask you one question, if you please: What, if any efforts have been made by the municipal authorities to lessen the amount of destructive material poured now by the sewers into Newtown Creek, and what difference has that made?

Captain Parsons: I know that some efforts have been made; I know that the question has been very thoroughly discussed from time to time but up to the present time I know of no material improvement. I know that one year ago we had a vessel of about one thousand tons capacity that was painted white inside, that is all her waist and houses, etc. were painted white, and she went into Newtown Creek to load, and her captain requested me to go over and see the vessel because she was in such fine condition. I went over when he had been there two days, and the vessel, all her white paint, had turned almost black and there was nothing about
200 the appearance of the vessel which would invite the inspection of one who felt any interest in her. That, I will say, was just about one year ago.

Col. Knight: I would like to ask, in connection with your re-

marks about that, I would like to call your attention to this extract from the New York Bay Pollution Commission report: "That the reduction in the numbers with the depth is striking and indicates that most of the sewage and other decomposible refuse with which the bacteria were associated was floating around at the surface and not mixing uniformly with the water." That is from the report of the Pollution Commission of New York City.

Captain Parsons: Well, I remember reading that document.

Col. Knight: But you disagree with that?

Captain Parsons: I disagree with that to this extent—as I said,—but there is more of it manifest upon the surface; that is, more of it deposited at the surface of the high water, yet it prevails all the way down as far as you can see it where the water leaves the ground.

Col. Knight: Well, if you could judge by simple figures, the difference between five feet and forty feet is the difference between one hundred per cent. and twenty-five per cent.; that is simply the report—taking those figures for it——

Capt. Parsons: A vessel that is so unfortunate as to be sunk in those waters anywhere around where Gowanus enters the bay, will immediately commence to accumulate a deposit of sediment
201 and the expense of the removal of that sediment from the vessel is very often equal to the expense of raising her, so thoroughly has this deposited itself all over the inside of the vessel, adding greatly to the weight of the vessel and making the raising of the vessel that much more difficult.

Mr. Dean: Mr. Chairman and Gentlemen, the next speaker we have to offer is Professor Landreth of Union University and dean of the engineering school there and who, for ten years, was consulting engineer to the New York State Department of Health, besides a great deal of other experience. He has not prepared a set speech and it may be found convenient, to jog his memory, if I may be permitted to ask him a few questions as he goes along in the stages of the questions or subjects we expect him to talk on.

Prof. Landreth: Mr. Chairman, I have been asked to say at first a few words concerning an outline of the history of the activity and the position which has been taken by the State of New York with regard to the comprehensive question of the sewage of this Metropolitan district, regardless of State laws, not only as a proof of the activity of the State of New York and in its efforts to solve this matter comprehensively and effectively, but also as a basis for just one or two statements I wish to make concerning my personal observations in the Harbor.

In the year 1903, I think it was, the State of New Jersey,
202 by the Passaic Valley Sewerage Commission, first proposed to discharge sewage into New York Bay. At that time the State Commissioner of Health of the State of New York determined to investigate the fact, and, on inquiring, concluded that it was a matter of sufficient importance to draw it to the attention of the Governor; which he did. The Governor at once concluded that a commission of inquiry was desirable and a bill was accordingly, at his request, passed by the legislature of that year, providing for the

establishment of a New York State Commission, or, better, called the New York Bay Pollution Commission having for its object principally the examination of the relation of the proposed sewerage discharge from New Jersey into New York Bay and its probable effect on the commerce and navigation of the bay, as well as its sanitary relation.

On studying the question for a year or so, that Commission, first, reached the conclusion that it was undesirable that that sewer should be constructed; secondly, that the question was not a small one, and that it was not confined to the case of the Passaic Valley sewer, but that many other problems were concerned intimately with it, first of all the problem of the disposal of the sewage of New York, Greater New York and, as a corollary to that, to dispose of and purify the sewage of the metropolitan district; and that Commission reported; in its report it recommended the establishment of a commission of wider power which should coöperate with a similar one from the State of New Jersey to study the matter in a comprehensive way,
and to reach conclusions as to the ultimate disposal of the
203 sewage of the entire district so that whatever efforts should be made for the adoption of such plans should be made along comprehensive lines and should not result in the throwing away of useful funds and efforts, but in the correction of abuses.

Thereupon the State of New York provided a second Commission, the term of the first having expired, after, in fact, having been extended by request of the Governor, for a year to take the matter up more fully, and in the latter part of 1905 the State of New York established a second Commission, called the Metropolitan Sewerage Commission of New York, and while that was a Commission established by the State, the expenses of the commission were to be paid by the City of New York and the appointments were made by the Mayor of the City of New York, and that Commission commenced its inquiry in 1906, and is still in existence.

For the first, I may say that I was a member of the New York Bay Pollution Commission, and, also, for a year and a half a member of the Metropolitan Sewerage Commission. I say that simply to explain my reason for appearing before you and stating these facts.

Now, the efforts of the State of New York to coöperate with the State of New Jersey have not been satisfactory. An invitation from the State, through the Secretary of State to the Governor of New Jersey to have a similar body appointed resulted in the matter being referred by the Governor
204 to the State Board of Health of New Jersey, and no satisfactory coöperation ever resulted from that Board, so that the State inquiry as to the ultimate disposal of the sewage of the entire district has been carried on by the two States distinctly and independently, without coöperation So much, Mr. Chairman, as the basis for the observations which I am to refer to.

The question as to the swing of the tides and the swing of the sewage borne above them in the Harbor has been mentioned. Floats placed in the harbor at different points at the beginning of the ebb

tide, make trips of different lengths according to the state of the tide, whether it is neat tide or spring tide; also according to the direction of the wind, although precautions have been taken to eliminate as far as possible the influence of the wind, that has not been fully successful, so that the lengths of the runs are not entirely sustained,—they are modified or disturbed by the effect of the wind. They, usually however, may be said to represent the flow of a float of from ten to fifteen miles, consequently the flow of the flood for that distance. Floats have been placed at the Battery at the beginning of the ebb and have passed out as far as Sandy Hook. At other observations, the floats have not gone so far. Similarly, floats have been placed at Sandy Hook which have come up above Robbins Reef, and where observations have been made——

The Chairman: That is on the flood tide?

Prof. Landreth: That is on the flood tide, yes, sir; and in
205 some instances they have shoaled on the shore. The swing of the tide does occur. These observations leave the progression, besides, towards the sea; that is, the movement is clearly towards the sea, but it is by no means an overwhelming one.

These observations, coupled also with observations of the density of the water as determined by current determinations, indicate that about one-half or something less than half of the water which goes out of the Narrows never returns; that the remainder is the same water which went out. That fact is, I suppose, largely accounted for by the fact that the sea-way beyond the bar is not an open sea entirely but is confined between the two lands at right angles,—the Jersey shore on the North shore, of Long Island shore Eastways, and it disappears into that, acquiring a large standard figure of the flood tide drawn up in the same way and returns in part the same water that went out on the ebb.

Concerning the matter of deposit, the borings that have been made,—a good many borings have been made on the bottom of the harbor by apparatus designed for bringing up samples not only from the surface but from several points below the surface simultaneously, and these borings show very general deposits of mud, largely organic in appearance and, as far as can be detected, it has the organic contents, all the essentials of organic sewage which has passed through a fairly advanced stage of decomposition and some of it having, at last, reached the mineral stage, where it is generally similar to natural mineral material and it all contains the
206 characteristic sewage indicator, the B colae comus. At a depth of from six to eight feet, as I recall—I am speaking from recollection merely—I am not positive how deep the B colae is observed in the mud, it is very general, however for the first foot or two, in fact in some cases increasing frequently as the distance into the mud is penetrated and rapidly diminishing below that point——

Mr. Dean: Professor, what would that B colae show?

Prof. Landreth: The B colae would show original sewage or animal contamination.

Those, gentlemen, are much better observed where—that is I speak as to the phenomena—on the inner slope of the bar at Ambrose

Channel, and the observations which were made at the available places, indicated, as you of course know, quite a large amount of organic matter, of harbor sludge or harbor deposits has formed on the inner slope of the bar. Borings from there involved a cross-section of the bar where the sand is fairly clean, to a depth of eight to twelve feet on the inner point of the slope and diminishing then up to the normal shoaler flatness further up the Bay, suggesting a possible explanation that in the efforts of the material in going back and forth and lying close to the bottom, still moving partly in the sand wave, to reach the sea, but practically moving back and forth in the same place, partially influenced by the current, somewhat will accumulate on the bar.

I should like to add only one or two words to the exposi-
207 tion of the Boston construction and the conditions there as compared with New York, which Dr. Jackson very clearly set forth, and that is, to emphasize the fact that New York has one outlet to the sea through which sewage may pass, and doubtless a remote one through the East River channel, whereas Boston has five or six, contributing, therefore, to a much more effective mixture of sewage with water in the case of Boston than in the case of New York. I should say that doubtless very little of the sewage of New York Bay does pass out through the East River; the borings into the channel of the East River and all the analyses that were sent to us showed a practically clean bottom. No deposits, practically, were found in large portions of the channel of the East River.

Mr. Dean: What would you say with reference to the proximity of the sea, at the Boston outlet, as compared with the proximity of the sea at the New York outlet?

Prof. Landreth: I should call it open sea just beyond the islands, in the case of Boston outlet; it is so cleanly swept by the winds and by the ocean movements there, and not at all land-locked as in the present case, as it is but a short distance from the margin or border of Boston harbor out to the open sea; of course, the depths are not as deep as they are farther off coast, but there is a clear and undisturbed sea movement, both of the waves and of the winds and, as far as the purposes of dilution are concerned, it is practically adjacent to the sea.

Col. Knight: But as far as currents for removal are con-
208 cerned, not as good as the currents coming down East River?

Prof. Landreth: I am hardly prepared to say that.

Some comment was made yesterday as to the prevalence of activity in sewage disposal in this country. I have simply jotted down some of the sewage disposal plants built in the State of New York; a large number of other cities in the country are considering the matter; some have actually built plants; most are in course of investigation; the construction that has already taken place in this State of sewage disposal plants has been in the following places—this is not at all complete, and depends on my memory—At Albion, there is a sewage disposal plant for the State institution; Rockport has one of a municipal nature, constructed and maintained by the corporation; so also,

with Depew; so also with Doala; so also at Far Rockaway, and I might say that they are now investigating the matter with a view to the establishment of a plant at Sheepshead Bay; at Skaneateles they have a plant either under investigation or actual construction at the present time; the City of Hudson has a plant for the treatment of a portion of its sewage; I should say, that the City of Hudson has a State institution. The City of Kingston has been treating part of its sewage. The village of Saratoga has a complete plant for all of its sewage, which has been very successful; the village of Ballston treats all of its sewage; the City of Gloversville does a portion of its sewage and is investigating the question more
209 fully before embarking on a complete plant. The village of East Syracuse has a plant; the village of Auburn has one plant just about done and are advising as to the construction of another. The City of St. Louis, as you may know, is considering this matter. Of the remainder of the cities,—I may say that there is a number of small institutions and villages, smaller than those I have mentioned which have this matter actively under consideration or are actually constructing plants. Thank you, gentlemen.

Mr. Dean: Professor, with reference to the tendency of the sewage to rise as soon as it comes from the opening of the sewer into the bay, and then its future course, taking up the question of sedimentation; what would you say on that?

Prof. Landreth: Well, as a matter of observation that sewage does rise on its discharge from the sewer into the bay; it is a matter of speculation as to what happens then, but it is a matter of observation that sewage sludge is found on the bottom; we can only conclude that it must have been deposited after having first come to the surface; we know that some of the material does deposit at once,—the mineral portion; it is a fact that the sewage does float and does deposit, and where these conditions predominate there are two complaints, the surface complaint and the bottom complaint.

Mr. Dean: Then, Professor, what would you say with reference to the percentage of solids, organic and inorganic, in sewage
210 in solution as compared with that in suspension, and the possibility of the removal of either by any method?

Prof. Landreth: Ordinary sewage will usually show a larger proportion of its solids in a state of solution; I would say, from fifty to seventy per cent., will be in solution, and, sometimes, the percentage is higher than that, and the remainder, from twenty-five to fifty per cent., will be in suspension.

Now, as the action of sea water, like the action of other precipitating channels may be, and in many cases is, to change the state of some of the dissolved matter into suspended matter, by rendering it insoluble, and causing it to precipitate.

This is markedly the case in artificial experiments to determine the effect of salt water, and it is exactly the case in the sewage of Worcester, Massachusetts—which is an iron-manufacturing town, that is, its interests are very largely concerned with the manufacture of small iron products, and many of them employ the galvanizing processes, in which the thickening of the iron is part of the opera-

tion. The thickening is done by the use of sulphuric acid, and the effect of the operation, besides thickening the iron, is to produce a residual sulphate of iron, which is a precipitating chemical.

The action of that chemical, as it is discharged into the sewers, is shown in the results of the tests, in the sewage plants there, in which a larger portion of the solids which are in solution, are
211 converted into solids in suspension, than is the case in sewages where this precipitating chemical is not present.

Manchester, England, is a somewhat similar case, but to a lesser degree. Manchester has some industries similar to those at Worcester.

Col. Knight: Do you know who were the engineers for the State Sewerage Commission, about 1902?

Prof. Landreth: Of New York,—or New Jersey? I have forgotten.

Col. Knight: New York?

Prof. Landreth: Of the State Sewerage Commission? I have forgotten.

Col. Knight: I have an extract here of the report of that Commission, which shows, among others, Messrs. Rudolph Hering,—J. J. R. Croes,—as engineers of the State Sewerage Commission of New York. Now, you are in a position to know something as to the reputation of engineers, are you not?

Prof. Landreth: Yes, sir; somewhat.

Col. Knight: Are you sufficiently posted to pass upon whether the reputation of those men is above the average as experts on this subject?

Prof. Landreth: Decidedly above the average; yes, sir.

Col. Knight: Decidedly above the average; their opinions should be given weight above the average?

Prof. Landreth: I should say above the average.

212 Col. Knight: Now, this is taken from their report (Reading):

"The sewage should, therefore, be partially purified: that is, as far as it is practicable, by works on the Newark Meadows, before being discharged into Newark Bay, or, it must be carried five miles further, and discharged in its raw or crude state, into deep water of the upper bay of New York, where there is a large volume of water and a strong current to insure thorough dilution and inoffensive dispersion. * * * The outfall of the sewage would leave the shore at an elevation of about twenty feet above high water and extend about two miles into the bay to a point North of Robbins Reef ledge, practically in the centre of the bay, in the vicinity of which the channel is seventy feet in depth."

That is the statement then, of those men, whose reputation is far above the average, and are to be given, in the expression of their opinions, credence above the average statement——

Prof. Landreth: Their reputation, I think, is far above the average——

Col. Knight: Well, have you anything—do you care to say anything to gainsay that or in opposition or in refutation of it?

Prof. Landreth: I do not wish to question the good judgment of men who have seen the service and who possess the ability of those engineers; it is sufficient for me to say that they were engaged by and were reporting for and in the interests of the Passaic
23 Valley and not of New York or the entire district. Just how far they took into consideration, in an impartial manner, the conditions and effects on other communities and other States, I am not advised. I infer that they gave that some consideration.

Col. Knight: You have nothing, then, definite, to advance in argument against that statement?

Prof. Landreth: Simply that I could not agree with that statement as to its probable effect on New York harbor conditions; looking at it in a broad and large sense, without regard to State lines at all I do not consider (and I do not offer my opinion as equal to Mr. Hering) I do not consider, myself, however, that it is a desirable thing to discharge sewage in the form proposed into New York harbor. That is my view; that is just my view, based on my observation and experience; however, I do not suggest that it has as strong weight as that of the New Jersey engineers there stated.

Col. Knight: But you admit this part of it——

Prof. Landreth: That part is a matter of opinion——

Col. Knight (continuing): You admit that part of it is a matter of opinion; but you admit that there is a large volume of water and a strong current to insure a thorough dilution—would you admit——

Prof. Landreth (interrupting): I would admit that there is a large volume of water and a strong current; but I am not positive that it does always insure "thorough dilution."

Col. Knight: You are not positive about that?

24 Prof. Landreth: No, sir.

Mr. Dean: Mr. Chairman and Gentlemen: With reference to the last point which you brought out, about the difference of opinion among the engineers, as Professor Landreth would not wish to contradict the opinion of all those gentlemen, with your permission I would like to read a paragraph of the opinion of Professor Allen Hazen: That extract is as follows (page 28):

"With regard to the Robbins Reef outlet, such a diversity of opinion exists among the engineers as to the probable nuisance that would be created by the Passaic Valley sewage if allowed an outlet at this point, that it would be advisable to have the combined action of New York and New Jersey sewage commissions to determine whether this outlet would be practicable."

And, another quotation, a short quotation, on page 93 of the same report:

"It must be admitted that New York is better off without the discharge of New Jersey sewage. The discharge of sewage will tend to pollute the Bay locally. There will be an appearance of sewage for some distance around the proposed outlet, and this outlet is near the main channel up the harbor. There will be some odor, and grease from the sewage will smoothe the waves and show its presence

over a considerable area. To a certain extent these phenomena are disagreeable and objectionable, and if New York could compel them to build the sewer or dispose of the sewage without damage to others, it is clearly for her interest to do so."

215 That is the opinion of one of their own engineers.

Mr. Riker: Won't you read the next sentence?

Mr. Dean: Shall I read the next sentence, that he wishes me to read?

Col. Knight: If you please.

Mr. Dean: At the request of the attorney for the petitioners, I read:

"New York is now putting practically all her own sewage into the harbor."

And that is a point which I did not wish to touch on, but, since they have brought it up, and with your permission, I would like to say a word on that point: The conditions are not at all similar between the deposits of the sewage of New York City and that of the proposed Passaic Valley sewage, for this reason: that the sewage from New York City, including Manhattan Island and the other boroughs of Bronx, Brooklyn or Kings, Richmond and Queens, finds its way into the water along an immense shore-line through a great many sewer outlets which have been counted and, as I recollect, number three hundred and sixty; this allows an immense amount of dilution with the water contained in the different rivers and it furnishes an entirely different example than where an immense amount of sewage is discharged through one opening in one particular place.

Assuming that there is, and will be, an immense volume of water passing over the Robbins Reef outlet, for a certain area the sewage, as we have heard, will tend to rise, and cannot possibly mix

216 with the immense volume of water which is at that outlet, and would result in this sewage passing out and spreading out over the surface of the entire width of the channel.

Referring back to the disposal of the New York City sewage, we must consider that the sewers of New York City have been constructed during a long period of time, ever since New York City was a small village; and it is only in the light of recent discoveries and experiments in sanitary science that methods have been discovered for disposing of sewage, and that many different plans have been considered for disposing of the sewage of New York City, and that some plans have been discussed and are, in fact, under very serious consideration at the present time, by which New York City can take care of its sewage.

Some two or three weeks ago, I had the pleasure of appearing before Governor Hughes in reference to the pollution of the Hudson River, on the request of some twelve hundred petitioners who were complaining, and Governor Hughes said at that time that it was one of the most important matters that had come before him during his administration, and that he hoped that some comprehensive plan would be devised within a short time to take care of the polluted condition of our rivers and our harbor.

I am also informed, by the State Commissioner of Health (Dr. Porter, who appeared here yesterday) that steps were being taken to amend the public health laws in New York State in this re-

It is quite true that the laws of New York are not, at the present time, sufficient to wipe out the nuisances which are now arising. Efforts have been made in this direction, but the laws at the present time are in such a condition that we cannot compel a municipal or individual interest to stop polluting the rivers or to stop polluting the harbor. All that the law permits, in this State, at the present time, is that no new sewers can be constructed without permission given by the State Department of Health, and Dr. Porter put himself on record here as to the policy he has pursued on behalf of the State to prevent further pollution of the waters of the State by sewage. He is utterly opposed to the construction of sewers in the future, and he has refused permission to sewers wherever he could do so; he is urging the cities, both large and small, and municipalities all over the State, to put in disposal plants.

When we consider that only fifteen years ago, the first disposal plant was in practical operation in New York State, we can see that this is only a recent movement, and that some time must necessarily be taken before the laws can be brought to a condition where they can, in a comprehensive manner, dispose of these questions.

At the present time, a nuisance may be taken care of by the local boards of health, but as Governor Hughes said, or intimated, the trouble with the law is that the local boards of health often fail in their duty owing to the fact that they are generally doctors or men who have other connections with the large business interests, and they do not wish to antagonize their clients or the local interests, and that the laws must be amended so that the necessary action can be placed in the hands of the State Department of Health—as it is in Pennsylvania—and that is the action we hope to take.

As Professor Landreth pointed out, action has been taken by this State looking towards some comprehensive coöperation in this matter of sewage disposal, with New Jersey. In 1904, the Commission of which he was a member, the New York Bay Pollution Commission, held two meetings with the State of New Jersey commissioners, but so far as reaching any conclusion is concerned, they have been without any result.

As I pointed out, the offensive results of the New York City sewage, are not the same as would be from this big sewer, as proposed. In the present light of sanitary science, there is apparently no excuse why such an immense big sewer should be built. Considering the two applications, it is estimated that the sewage of New York City amounts to five hundred million gallons per day. These gentlemen propose, as you know, to discharge, at the beginning, one hundred and twenty million gallons per day, running up to an average, as Mr. Harrison stated yesterday, of two hundred and fifty million gallons further per day, and they estimate a maximum capacity of

three hundred and sixty seven million gallons per day. Of course, that is the maximum; but the policy of this State, and, I might say, the policy of New Jersey, at the present time, is towards correcting these sanitary evils.

219 It must be remembered that the Passaic Valley Sewerage Commission is a local body, and is not amenable to the State Department of Health of New Jersey, in its action. I would like to add that the reports, which I gather from the newspapers are, that the State Department of Health of New Jersey has recently taken action against the cities of Riverton and Camden, on the Delaware River, and Phillipsburg, also on the Delaware, and Seabright, on the Shrewsburg, to compel those cities to stop polluting those rivers; so that the State of New Jersey has placed itself on record as being opposed to pollution, while this Commission, which is not amenable to any State Department of Health of any State whatsoever, is seeking, in its own way, to dispose of its own sewage, without reference to what the effect may be upon the surrounding country.

I would like, if possible, but the time does not permit, to go into the alternatives which they may take up if they choose; but I would like to refer to just one statement that Mr. Hering made at Montclair, on October 20th which I personally heard; that, if this trunk sewer were not to be constructed, then they could build a sprinkler and filter which would do the same work, and that that sprinkler and filter could not be smelt five hundred or six hundred feet away from it, and that it would be cheaper to construct that sprinkler and filter than it would be to construct the tunnel which would extend through this territory from the shore of Newark Bay and under Newark Bay, with the accessories, out to New

220 York Bay. He said that it would be cheaper to construct that disposal plant than to construct the other system,—the trunk sewer, although it would cost slightly more to maintain it——

Mr. Riker: That statement applied to Montclair only, as to the cost, on account of its location, and did not apply to the other communities who are concerned in this project——

Mr. Dean: I did not understand it that way——

Mr. Riker: Why, certainly, the question that was discussed was as to the cost to Montclair——

Mr. Dean: I will question Mr. Hering——

Mr. Hering: My statement was that we might have to consider the erection of a sprinkler plant in time——

Mr. Riker: The question being whether Montclair would come into this project with the other municipalities, and the chief question referred to was the price to that community, to Montclair, and Mr. Hering's statement was that the filter arrangement would be more expensive——

Mr. Dean: Mr. Hering, does that statement in fact conform to your recollection,—is it in conformity with your remarks then?

Mr. Hering: I am sorry to be obliged to differ with the Judge. I was asked to go out to Montclair, to go to a meeting of citizens,

there, to inform them what the plan was, of the Passaic Valley Sewerage Commission; what they were going to do, because most of them were in ignorance of the details, and part is correct, what the gentleman has said, that I said it will cost less money
221 to put in a disposal works to purify the sewage of the whole district, but it will cost so much more to maintain it; that, estimating, as we should do in every business into which intelligent business men embark, the sinking funds, depreciation, interest on the amount invested, plus operating expenses, the total real cost of the work is greater, not cheaper; that Montclair would have to pay more if her sewage were purified in a disposal plant in the Newark Meadows, than she would if the trunk sewer was built as proposed—that is what I said.

Mr. Dean: May I be permitted to ask a question? If the individual municipalities in this district build their own disposal plants, would it not be more expensive to them—would they not make money by joining in the building of this trunk sewer?

Col. Knight: The answer to that is?

Mr. Hering: The initial cost, where such plants could be erected at all, might be less, would very probably be less, but the cost of maintenance would undoubtedly be greater.

Mr. Dean: May I call the Board's attention to a paragraph or two in a letter written by Col. D. W. Lockwood, of the Corps of Engineers, U. S. A., dated February 2d, 1907, with reference to the disposal of the Bronx sewage? Shall I read these two paragraphs, or simply put the matter into the record?

The Chairman: Read it.

Mr. Dean: The letter—in a part of the letter, it says,
222 with reference to the Bronx sewer:

"The effect of sewage discharged into the waters of New York harbor is shown by material being removed at the North end of Ambrose Channel and through channels elsewhere. To be sure, this discharge has been going on for a long time, but it is increasing very rapidly, and before many years it will be found not only desirable, but imperative that some comprehensive system of sewage disposal other than that now in use be adopted which will keep the solid constituents out of the harbor, besides rendering innocuous the liquids allowed to run, as now. The proposed sewer will add but little to the present unsatisfactory sewage conditions prevailing and from the best sources of information available it appears that the quantity of solid matter which it will carry to the river will be comparatively small, at least for a number of years. It is therefore recommended that no objections be raised to its installation, particularly as it would be included in any general plan for reorganizing the sewage system to the New York harbor that may come up in the future."

I wish to add that the population which will drain into the Bronx sewer at the beginning would be at the rate of only from twenty thousand to forty thousand people, so that it cannot be considered as a precedent for discharging the sewage of the Passaic Valley into the bay.

With reference to another letter, a letter of this Board, dated, New York City, May 28th, 1897, at page 53 of the report
223 of the commission on the sewage disposal of the city of Paterson. This letter, of the Harbor Line Board signed by the engineers, refers to the refusal of a permit to discharge sewage into Newark Bay, at which time it was estimated, in the third paragraph on page 53, that the entire amount of sewage which would be deposited in Newark Bay would amount to seven hundred and fifty-five thousand gallons per day; and, in the next to the last paragraph on the same page, it reads as follows:—from the printed report of the engineers on the question of the sewage disposal of Paterson——

The Chairman: Is that signed by Col. Robert?

Mr. Dean: Yes, sir; Cols. Roberts and Raymond——

The Chairman: That was in 1897?

Mr. Dean: Yes, sir; and, of course, the conditions are worse now than they were then.

(Reading:) "The estimated annual deposit of six hundred and fifty thousand cubic yards of solid material in the lower end of Newark Bay, following the adoption of the proposed sewage system, would fill up the entire area of the Bay below the proposed sewer outlet, from bank to bank to the depth of about one-third of a foot annually if evenly distributed. As the existing average depth of the flats, except in the narrower width of the mud adjacent, is about four feet at mean low water, it is easy to see that it will require only a few years to make the proposed sewer system not only a public nuisance, but a serious obstruction to the navigable waters adjacent to the harbor of New York.

224 "The Board is of the opinion that, as a general rule, when it is desirable to discharge sewage or other material into tidal waters, it should be at points where natural deep water exists and not in the vicinity of artificial channels which require periodical dredging for their maintenance.

"Newark Bay is a land-locked tidal basin of considerable area, with comparatively small outlets, through which it will always be difficult to maintain channels of a depth adequate for navigation.

"The Board is of the opinion that it is not advisable to permit the use of such a basin as a receptacle for a large and constantly increasing amount of sewage.

"Even if the dilution of the sewage for which provision is now contemplated should be sufficient to prevent serious deposits, it is certain that the amount of discharge will rapidly increase and eventually produce shoaling in the channel.

"The Commission recognizes the fact that this sewage cannot be indefinitely emptied into the waters of the Bay, and that a time will come when other means must be adopted for its disposal.

"The Board concurs in the opinion of the District Engineer that the disposal of the sewage of the lower Passaic district in the waters of Newark Bay will be detrimental to the interests of navigation."

I wish to add that this subject was further considered by
225 the Military Secretary, Acting Secretary of War, as late as August 3d, 1906, the letter of whom appears on page 55,—it

does not state his name—of the same book, which I will not read, but it is to the same effect.

We have not attempted to estimate the entire solid contents of this sewage as will be discharged, and I simply wish to call to your attention that the average daily flow at the end of this period, at 1940, is estimated, as they say, at two hundred and fifty million gallons, which would be slightly over three times the amount they formerly proposed to empty into Newark Bay; and I also wish to add that if they are of the opinion that the sewage will be so clarified (that is the word which was used yesterday) in their proposed scheme, why should they go to the trouble and expense of building a tunnel under New York bay,—why do not they admit it into Newark Bay, instead of going to the expense of building this large tunnel? I think that the fact that they are expecting to build such a tunnel is an admission on their part that they would feel it to be folly to apply to this Board for permission to dump it into Newark Bay in the face of this report of the Board.

Col. Knight: Do you make no distinction between the physical conditions of Newark Bay and those of New York Bay? Of course, that has everything to do with the matter. The Harbor Line Board, whose report you have read, rejected an application for a discharge sewer into Newark Bay because of certain conditions,—do those conditions hold in New York Bay? As to artificial channels?

Mr. Dean: Of course, there are artificial channels in New
226 York Bay,—Ambrose Channel and other channels with which you gentlemen are much more familiar than I am, as a lawyer. We have had some testimony as to the amount of dredging occurring in slips and piers at the present time, and if a comprehensive scheme is fulfilled, to prevent New York City from the affliction of the offensiveness of this sewage, then the construction of this sewer would be a very great discouragement towards following out a comprehensive plan, and would, on the other hand, counterbalance any removal of sewage which New York City might be able to make of her own.

Then, the other reasons why these are to a large extent similar, is owing to the under-run which I admit is somewhat indefinite, and I can only refer your Board to the report of the Department of the Interior of 1886, or 1887, I think it is 1886, in which the subject of the underrun is considered. That shows that the water nearer the bottom of the Bay tends to stand still or, if anything, to move up towards the Hudson River and that while the current on the surface of the water may be going out, the under-run is coming up, and that the under-run under any conditions, even at the end of the ebb tide, does not go out as far or with as great velocity as the water does at the surface, which would show that the specific gravity—it is due to the specific gravity—keeps that water more at a standstill near the bottom, and that this stuff there, the sediment and the precipitants
from the sewage,—as the chemical and bacteriological action
227 takes place on the surface of the water, it sinks down into this water of greater density and washes back and forth on the bottom and settles near the bottom. Of course, the freshets in the

Hudson River would have a very large effect and tend to wash it out to a large extent, but in the late Summer or Early Spring, when the ice is still in the river, the water of the Hudson does not push the tide out as far, and that deeper, or underrun goes away up the Hudson River. That, of course, is all technical, but I am stating that as mere facts which I have derived from studying the different reports to which I have referred.

Col. Knight: Well, as regards the conclusions you can reach there, from studies of those different reports, you differ apparently with what we learned from the gentleman you asked to explain these matters to us——

Mr. Dean: Professor Landreth——

Col. Knight: You have had a statement from him as to the clear condition that the bottom of the East River is in, have you not? That was his statement, that it was clear?

Mr. Dean: Along the bottom of the East River?

Col. Knight: The East River; yes.

Mr. Dean: My impression from studying the different reports is——

Col. Knight: I only want his statement——

(The stenographer could not immediately locate in his notes that portion of Professor Landreth's remarks, and Professor Landreth was recalled.)

228 Prof. Landreth: I do not recall the exact form of my affirmation: I wished then to make it clear that the East River was the only spot where we found a clean bottom, in the harbor of New York.

Col. Knight: Now, then, in the report of the New York Bay Pollution Commission, they say the following: "From examinations of samples there, the water of the East River is shown to be very much more polluted, lately for many years than the waters of the Harlem or Hudson Rivers. * * * It was therefore decidedly more polluted". Consequently, in view of this statement, we would not expect that in waters which are more polluted, we would find, in that place, a clean bottom, unless you admit that there is some credit to be placed in the statements about the scouring power of those waters,—the preponderance of the ebb tide of the East River down through that channel.

Mr. Dean: I think that in explanation of those tests it can be said that those tests were made on the surface of the water——

Col. Knight: That is where you say this sewage is.

Mr. Dean: The bacterial action takes place, in a large preponderance, near the surface of the water, and as the bacterial action takes place, it decomposes this organic matter, which, as it decomposes, goes to the bottom.

Col. Knight: That is just what I say; you do not find it in the bottom, the current carries it away.

Mr. Dean: But the Department Reports will show, undoubtedly,

that there is a stronger current in the East River than there
229 is in the Hudson.

Col. Knight: Well, that water which comes down during ebb tide on the East River must continue out and does continue out.

Mr. Dean: I believe I recollect reading of the large body of water going through the Bay.

Mr. Ackerman: In this Hazen report, just referred to, I want to say I was secretary of the joint committee, and, in the clause quoted by Mr. Dean in reference to the appearance of the sewage for some distance around the proposed outlet, Mr. Hazen's deductions were made at that time on observations of the Moon Island and Deer Island outlets, the Nut Island outlet not then having been completed——

Mr. Riker: In Boston——

Mr. Ackerman: In Boston. And, furthermore, Mr. Hazen, at that time, had no plans of the Passaic Valley Commission; he was acting solely for Paterson, and was obliged to make his own observations, his entire observations, his own figures, from looking up the figures previously reported by the Passaic Valley Commission.

In view of the fact that Dr. Soper presented a paper yesterday, and Mr. Hazen's name has been mentioned, I wish to call the attention of this Board to a paper enclosed in this report (referring to book in hands of speaker) on the discharge of sewage on the New York side, being a discussion by Allen Hazen of a paper presented by Dr. Soper, to the Society of Sanitary Engineers of Boston, and on page 142: (Reading)—

230 "The quantity of water that comes into the New York harbor through the Narrows, and goes out again, if reduced to cubic feet per second, is a tremendous quantity; altogether, it represents a flow of over three cubic feet per second per thousand of population for one hundred million people. That is a pretty large population,—more than the present population of the whole United States, but there can be no doubt that, diluting the sewage from it, with this amount of clean, cool, sea water, and with the strong tidal currents which exist, would render it inoccuous and inoffensive."

On page 143 (Reading):

"Of course, it is also true that when New York reaches a population of twenty-five million, a great deal of it will be on Staten Island and on Long Island and so located that it will not discharge its sewage into the ocean through the barred harbor, and these computations that we previously make do not take into account the conditions of the lower harbor which are undoubtedly vastly more favorable for the dispersion of sewage, and so it looks as if it may be centuries rather than decades to the time when radical measures for purifying the sewage of New York City will be required."

I ask you to accept this report to the Board (proffers book, which is accepted by the Chairman, with thanks).

Mr. Lebkuecher: I desire to ask the privilege of the Board and the Government, as represented by the Board, to give us permission to refute some of the statements that have been made in
231 opposition to this application; for instance, the Boston harbor discharge was referred to and only the Moon Island discharge

of that City, whereas there are three discharge points in Boston harbor, and the one referred to is the oldest one of all, which has been in existence, as I understand, for over thirty years, and found to be inadequate, and newer ones have been installed on more modern lines—plans. Now, generally speaking, we all admit that it has been found that the sewage problem is one of the problems of the civilized world,—all over the world,—the civilized world, and it has been said that, fortunate are those communities who, located near the sea, where there can be a discharge of sewage by dilution. We fully understand—as a member of this Commission I desire the members of this Board to understand that this Commission has made a thorough study of all methods of sewage disposal and the trouble about the disposal of sewage is universal,—all over the world, except where it can be diluted in sea water.

This past Summer I made it my business to study sewage disposal works and observe them, and I have gone to Europe, and in England,—made it my business to see what is being done in that line, and, while theoretically, sewage can be disposed of artificially, through filtration or sprinkling systems, sedimentation, and all that sort of thing, I want to say that I did not see a single disposal plant that was theoretically perfect,—that is, up to the theory of the engineers of the disposal plants; these disposal plants were all
232 practically alike, all more or less of a nuisance; it didn't make any difference which system was in use, they were all more or less nuisances; sometimes they worked all night; sometimes they did not.

Now, in this matter of the disposal of the Passaic Valley sewage, our law allows each community to dispose of it as it sees fit,—to go into contracts with this Commission, and to make one job of it, or to dispose of its sewage as best it may.

We think, and it seems to me that it is very evident, that this section is a part of the metropolitan district; it gets its population because of the metropolitan district, and it seems to me unthinkable that there should be twenty separate disposal plants, one for each of those municipalities to be installed in order to get rid of the sewage.

The matter has been thoroughly studied, and I do not understand how the New York people can come here and ask the privilege of continuing the disposal of the sewage of ten times as many inhabitants in the bay and harbor of New York, and then object to the extra one-tenth from a community which is a part of this same district.

And, furthermore, we have made a study of it as to the question of pollution, and for that very reason it is that we want to diffuse it as much as possible; the idea is to have a large area on the bottom of the bay, with very many openings to give it ample chance of dispersion and assimilation.

As long as the population of that district was small, the
233 Passaic River was amply able to take care of it,—it dissipated it, or ate it,—for that is what water does with sewage if the pollution is ample; and we feel sure that there will be no perceptible pollution on the plans as outlined by our engineers.

I would like Mr. Hering to explain why some of the statements made by the opponents are not fully correct as far as the Boston situation goes.

Mr. Hering: Gentlemen: When I was here yesterday, I did not know that I would have to say anything about this matter, and I was absolutely unprepared, and I ha dan engagement last evening,—so I did not prepare a statement for you, but I will speak off-hand, as my memory recalls such things as have been said.

I, first, would like the privilege of answering Mr. Landreth. I would not like to have the Commission believe, for a moment, that my principles of life were not different from those which I am afraid you might infer from what Professor Landreth stated. I never engage as a partisan in any piece of work, whether I am testifying in court, or whether I am engaged by a municipality.

When I was engaged by the Passaic Valley Sewerage Commission to suggest to them what they should do here, I might have said,—"Discharge it just like Hoboken does,—just like Jersey City does, right out of the sewers," the way New York City allows it to be done. I did not. I, realizing that this was a community only theoretically separated by the State lines, recommended,—my
234 recommendation was that it should be put where it will not harm the City of New York or this great metropolis, although it required New Jersey to spend a good many million dollars more to do the work just for that purpose, and no other. That was my recommendation, and no other. I was just as much looking out for the interests of New York as New Jersey, although I had no New York position at that time.

I would also like to answer my friend, Dr. Jackson, who, I thinks, perhaps misrepresented himself in some respect to your Body, in speaking only of the Moon Island sewage disposal of Boston, and perhaps thus leading us to suppose that that was what is going to be done here.

I remember when the Moon Island plant was built; I know why it was designed just as it was; I knew the chief engineer very well, visiting the work while under construction. It was the best system then known to deal with this sewage, and also the least expensive one for that part of Boston. They all saw the objectionable features of that method of disposal, and the next opportunity they had, to put in the works at Deer Island, they used a very different method there: Why? Because better. They discharge at all times; they do not do as at Moon Island, start up after the ebb tide has begun, and where they partially purify the discharge as at Moon Island, we will say that it does discharge on the surface,—the effects are not so bad as some of the stuff that floats around the harbor of New York to-day; and I would like to say that I have been out there a number of times,—only a year ago again, and that was dis-
235 persed entirely, so that you cannot see it, inside of two hours,—although the surface is black appearing and offensive, especially after you get out a mile or two,—I think it is possibly all gone——

The Chairman: Where is that? Deer Island?

Mr. Hering: That is at Moon Island. Now, at Deer Island they discharge this sewage at all times; they bring it out and turn the pipe up, in an upward direction, quite near the surface, so that at low tide you can actually see the rise of the water, due to the forces of the discharge, raising the surface, and as it is quite near the surface, naturally you see it flowing over the surface there. That is not the right way to dispose of sewage; they realized that,—so, when they built the other work at Nut Island, they discharged it at the bottom, further down, so that it has a greater distance to come up before reaching the surface, and in my humble opinion I think it is an error, the way they have built it, because they have carried the whole pipe right straight out to the outfall, giving this fresh water sewage a velocity, I think of three or four feet a second to start right up to the surface, and, naturally, it comes up to the surface if it gets a push equal to that, and yet, notwithstanding this condition, thus added velocity, and the single discharge, it is not nearly as perceptible as at Deer Island.

I think that the method proposed here, which is to discharge it in small outlets for dispersion, is far in advance of anything at Boston, and will be effectual. Then, another matter, to obviate this velocity, this shooting up,—as has been stated,—the proposition here
236 is to discharge it horizontally, which is much better, because it shoots out at a velocity of about three feet a second, and now, discharged horizontally, it has got to come to a dead stop before it can move in a vertical direction, and then, with the vertical openings in the horizontal discharge pipes, there is nothing to give it a push upward, nothing to cause it to rise up; therefore, the tendency to go up will be much less here than in any of the outlets at Boston. Besides, we all know that a small stream will disperse very much more rapidly in the element into which it is discharged than a large stream. This you can see even if you have a pitcher of water, or, perhaps, a tank, and you squirt into it a stream of water, perhaps a quarter of an inch in volume, dirty water squirted into your receptacle, and you will see how very rapidly it is dispersed.

I think that the Moon Island proposition as mentioned here is not at all to be compared with what we are going to do, and even the other plants at Boston, which I have mentioned, I think should not be compared, and the effect on the surface of the water ought not to be compared with what you are going to have here, because of the reasons that have been stated, and the different methods of dispersion suggested.

The Chairman: You say that the sewage that comes out at Deer Island outlet has been treated before it is discharged?

Mr. Hering: Well, it is screened partially; and right there I might take up the question of screening again: The screens
237 there (Deer Island) I believe, are one inch apart,—I am not sure but I should like to state, in view of the fact that yesterday some weight seemed to be given to the fact that there was no specification of just how the sewage was going to be screened and how it was going to be settled; I would like to reply to that.

This matter of screening is a subject that has been studied very

carefully for the last two years; in Europe we saw all sorts of screens there,—wide ones, of an inch opening, down to a millimeter. Measurements, of course, have been made as to what that takes out, and there is not such a great lot of difference; the results vary from ten to twenty-five per cent. of the entire suspended matter.

Now, the finest screens that I have been able to find in use were in Europe, and we have, I think, one of the finest in the world here in this country, and they do not take out twenty-five per cent. of the suspended matter. Now, what is the difference? Is there a great difference between ten and twenty-five per cent. as regards this proposition? I do not think so. The difference is here: you must take out everything that is visible; everything that is large, and those are the screens that are proposed to be put in here, and all the screening used in Europe is that they take out all the larger matter,—there is no percentage there.

But, when you speak of the suspended matter in general, you must include, also, the very fine matter which goes through the
238 screen, and which is the bulk of the matter. There is another difficult point,—you might ask, how could that statement throw a great deal of light on the subject? That is, to be more definite about it, we have a difference here: we have the Paterson sewage, coming down twenty miles through the sewers, all broken up, yet going through the screens, in a different condition from what the Newark sewage would go. That whole proposition is so complicated that it can be worked out only after a good deal of study and observation of it, and so on, for which no funds have yet been spent, and which, I must remark, must bear some relation to the amount of dilution necessary at that time,—because we know the screens will do the work. That settles this point.

Now, about the question of sedimentation; that is a question that has never been settled because it was, in the first place, a question of funds, and rather a complicated study, and chiefly because the Commission thought your Honorable Body, or the Army, would designate how much of that sediment would have to be kept out, and that merely means making the tanks a little larger or smaller; that is all it means, and, in the estimate of cost, enough was put in to cover that, so that I do not see that that is such a great thing to be known before you can say whether this proposition is worthy of adoption or not.

I was asked yesterday to get some information on the solid matters: I have had but very little time to look up this matter, and you know that sewage is a very changeable matter. You cannot
239 give an analysis and say that that holds good for all cases. Now, take, for instance, the European and American sewages; our sewage is about twice as dilute, and sometimes three or four times as dilute as European sewage. I stated, yesterday, that the amount of suspended organic matter in sewage was one in five thousand. Well, I was not certain about it, and I did not wish it to be held down to that; and now I find that that is the English figure; in our country it would be one in ten thousand parts because our sewage is twice as dilute. That is the suspended organic matter,—that which

foals, or part of which foals. Then the suspended mineral matter. This must be determined by the fact as to whether you have a combined system or a separate system,—which is a very different matter. If you have a combined system, you get all of your street wash, and that is a great deal; that is mineral. The abrasions from the street and from the horses' hoofs and the quantity of iron is quite material, and dust, mineral dust, and so on. So, I am now giving you a figure for the separate system, because this is to be a separate system (although temporarily Newark and Paterson still have combined systems, but for their own interest financially they will have to change and get separate systems). In a separate system, the suspended mineral matter is, taken roughly, one in twenty-thousand, or, the dissolved mineral matter is about one in six thousand. Now, there, you have got a general composition of the sewage, but it is very rough, because you really should have the particular kind
240 of sewage that you are treating with, and that is the general average of American conditions.

Col. Knight: What was your third figure there,—the dissolved mineral?

Mr. Hering: One in six thousand.

Now, I have already stated that the proportion of solid organic matter which can be screened out varies from fifteen to twenty-five per cent; that is the solid organic matter that can be screened out, and that is all that will float in this case.

With reference to the sedimentation tanks, as I say, they have not been designed; they can be designed on the basis of whatever figure is given by the United States Government. For instance, let me say, if you build your tanks so as to reduce the velocity to about six inches per second—I cannot state now that that is the figure to be adopted, it is not settled,—you can get out from one-half to one-third of the deposit matter—six inch velocity per second in the sediment tanks,—six inches sediment. Now, that is the figure that has been used elsewhere, and it is about right.

Now, I want to say that what does not deposit will go on, and go into the river. That is so fine that it makes the water look dark. I have here some data about the observations that were made by the Commission for Additional Water Supply in New York some years ago,—in 1903, in New York, as to the attributes of the water in the Hudson River at Poughkeepsie, and when I say that the sus-
241 pended matter that is, the organic matter, is one part in ten thousand, I mean one hundred parts in a million. That is merely as a measure, because I am going to give you now some of the properties of the water of the Hudson River, coming down from Poughkeepsie to the Battery. They range, of course, from nothing, which is clear water, sometimes, to four hundred parts to the million, and that is four times greater than the amount of suspended animal matter that would remain in the sewage, or would be in the sewage discharged after this sedimenting—no, without the sedimenting—that, that is without the sedimentation; that is all that would remain in the water not sedimented, in the unsedimented sewage,—about

four hundred parts in the million; that is the maximum that I see here during the month of March.

The data runs from two hundred to four hundred, two hundred and eighty, and so on, so that we have this point in view, that the suspended matter is very fine, particularly after the sewage passes through the systems of purification, after being screened and flowing through the purification works, that it has no more suspended matter than the river carries with it into which you are going to discharge. The plans call for the putting in of a basin or basins to remove the putrescent matter, and this is provided for and is part of the present most economical system of sewage purification. In the discharge of this sewage there will be nothing floating—although it is dropped into the river in the New York City system—and there will
242 be no nuisance or offense, because the amount of suspended matter that is in this purified sewage and non-putrescent discharge, is no more than what comes down in the river, therefore not making the river worse than it is in any way.

Col. Knight: You say that matter is non-putrescent?

Mr. Hering: Non-putrescent—the modern system of sewage disposal,—if you care to hear it——

Col. Knight: I would like to know why, if it is organic, you say it is non-putrescent?

Mr. Hering: It is not altogether organic. The modern system, the cheapest system is, purely, aeration by means of spreading the sewage over a bed of stone, through which it percolates, goes around the surface of the stone, which is exposed. Now, if the stone bed is to be permanent, and not require cleaning, everything that goes in must come out; therefore, whatever solid matter goes in and forms, must go out; this is effected by means of a non-putrescent flush, and the resulting matter is called in England, humous; this, being introduced into a river, is likely to make it turbid. Of course, in the European or English rivers, the waters are more clear, and they settle this out, but in our Southern rivers, for instance, where the streams are all muddy, it would be — thoroughly settled that it would cause nothing worse than what is in the river. But it is the proper method of sewage disposal, and by its means you get your effluent absolutely non-putrescent. I believe thor-
243 oughly it can be done; it has been done in England, is done here at the present time in one system—but there are still a great many unknown quantities about this method, and we are not at all at the end of the book.

Mr. Kissam: Before this hearing closes, I would like to make a few remarks. I represent the City of Orange——

The Chairman: Mr. Hering has not concluded his remarks as yet; you will have an opportunity to speak.

Mr. Hering: I was asked, also, to give some data as to just what happens to the sewage, and how far it would travel up the river after it was discharged at Robbins Reef Light, and I have not been able to get the data to make all of those calculations, but what remains is pretty simple. If the sewage is discharged at Robbins Reef at low tide, then, when the tide comes in it will all travel up

stream, go up the Hudson River and the East River. Just how it is to be divided, I cannot say now, but, let us say it goes up the Hudson River to a certain point. I cannot tell you how far it is. It would be a little difficult question to answer that yet, unless experiments had been made to verify it. You know, of course—I will make that statement to your honorable Body,—water does not run up like the body of a wheel,—it runs up faster in the centre of the stream than it does at the sides, and faster at the surface than it does at the bottom, and, therefore, to make any prognostication as to just where that sewage would go, or how far it is going, is a matter that cannot be answered off-hand.

Mr. Lebkuecher: How long will it take to dilute the sewage so discharged?

244

Mr. Hering: I think it can be diluted so that you could not see it at all within perhaps—well, I make a guess now, based on rather long steady study and experience—a few thousand feet from the place where it is put in. I do not think you would be able to see it.

Mr. Lebkuecher: But in the experiments with the aniline dye water showed it went how far?

Mr. Hering: Well, we did not know how far it went because we did not see it at all; the aniline dye water we put into the water at thirty feet below, we never saw again, but as this was only a preliminary experiment, so to speak, we did not think—we were not prepared to make any further investigation, presuming it could be done at some future time to find out how it is going below. All we were interested in was how soon it would come to the surface.

Now in this proposed sewer, we propose to discharge at fifty feet below the surface, that is, on an average of about forty-five feet, and if it does not come to the surface at thirty feet it would probably not come to the surface if discharged at forty-five feet.

Now, I cannot say how far it is going, but the very fact that it moves up the centre—whereas all of the New York sewage is discharged at the sides,—the Jersey sewage being discharged at the centre would keep those two bodies of sewage somewhat separate, if they exist perceptibly, as I do not think they will by the

245

time they get up to New York. I do not know how far the sewage would run up. I have not been able to look that up in the short time that I have had. Now, let us analyze, somewhat, this question: Some of the matter that goes in at the outfall will probably be coagulated, if it goes down deep into a saltier water than at the top, but that whole question is not by any means clear. I think it has been misrepresented often. I am sorry to say that I believe my friend, Dr. Soper, yesterday fell into an error in presenting two photographs here, of which I merely heard, but which say that sewage—but which would lead you to infer,—or might lead you to infer, that that sewage, discharged down here at this outfall, would deposit more in salt water than in fresh water.

I do not know how my friend, Dr. Soper, made those experiments, but that is not the way things are going to happen here. In the first place, we take out the suspended matter, by deposition. We

ke out the screened matter that is not in that sewage that you
t down there,—that is taken out, and the deposition,—that we do
o is material as that is just we propose to take out,—that is not
a the sewage that the Passaic Valley Commission proposes to dis-
harge into New York harbor—that is taken out by screening and
ettling tanks, and, therefore, I do not think it is a fair inference
o judge from a chemical experiment in a laboratory, what is going
o happen there. We just must know what we are doing.

Now, I also want to say this: That, in Europe, where they are working pretty hard on these matters, I heard statements
36 from prominent chemists—I am not a chemist myself and I do not wish to have you, sir, take any of my opinions on chemistry as final,—I heard that the experiments that had been made there on this subject of precipitation in salt water and fresh water under proper conditions, and proper water, showed that there was more precipitation in fresh water than in salt water,—against what I have heard here to-day stated. Now, no less an authority than Dr. Fowler, of Manchester, made that statement to me last Summer, and I will say that, within a short time, perhaps a month or two, the Royal Commission of England, which has been working on this matter for I don't know how many years, it is years—made a report on the discharge of sewage into tidal estuaries. It is a large blue book about two inches thick and in it, I think, very nourishing reading,—it has a great deal of information in it, by the best engineers and chemists of England—Dr. Fowler is quoted in the report, as is Mr. Adney, and Mr. Leets, and other prominent engineers, representative people, and they got through with their report; I have not gone all through the book, but I am quite familiar with its contents, as I had consulted with a number of those gentlemen last Summer, and know about what the results are. I have read some of the conclusions they reached, and was much gratified to find that the Passaic Valley Sewerage Commission had, to some extent, anticipated the report in the recommendations which they had made.

Now, we cannot take this question as final at all, whether
37 sewage is going to coagulate we know, but just how much, is another question, there is still a good deal to be done. I anticipated, of course, that the Passaic Valley Sewerage Commission, in due time, would make the necessary experiments to find out all the principles necessary to make their work beyond criticism. Now, some matter, I said, would be coagulated. Some matter will be deposited on the beds. Now, what is that? That is chiefly, gentlemen, pretty near wholly, the street wash water that comes out in the combined sewers. Now, this has been shown in Europe very nicely in cities where they formerly had combined systems of sewers and discharged right into the rivers; they got their sediment, and afterwards they took the sewage out and purified it; they had the same black deposit; not so much, but it is that same character. Where does it come from? Why, it is the surface wash from the city. In New York it would be the street wash, the attrition, the dust that deposits a particle, it is that which does not

usually get into the sewer. That is all cut out except the decomposible matter there, those stable fibres continue a long time, decompose slowly. It is not like animal matter, which decomposes very rapidly. This organic matter, which remains a long time, those shreds and fibres, they go down.

Now, that deposit finally, when the velocity gets so light that they will drop, drops down, particularly when you get near the ocean,—the bar is formed practically of just such matters, and, where there is no such deposit, it is formed of suspended
248 matter that comes down the river from the fields and forests, and so on,—that forms the bar, so, only the suspended matter that remains in the sewers, and that is the deposit on the beds, and it is of that character nearly always. The other is consumed. It is eaten up, either by the gross animal life in the harbor, or it is eaten up by the bacteria which fill this water here, given the presence of oxygen; that is to say, the water must not be diluted so that there is not a sufficient amount of oxygen to nourish the bacteria which you need to eat that up, so that most of that matter is dispersed in that way. Some actually goes out to sea.

Now, there you have the whole list of matters and every one has some value. We did not know what—I could not give you any figure at all. One guess is as good as another, but that is a matter, a subject which I hope somebody who has money to spend will some day investigate and illuminate the scientific world on,—how those proportions really are.

There is another matter I have not mentioned: That is, grease. A good deal has been said about that. They said,—I think some gentlemen said, and I think, also in the paper, that we would be able to see a big black grease spot at Robbins Reef Light. It would be right in the line or route of boats to Staten Island, and would be very objectionable. Now, there is no doubt about it at all, that some grease will come down; some of it will be kept back in the settling basin no doubt, but a good deal of it will come down here without question, and grease rises to the top, being lighter than fresh water. It will go faster than fresh water, but I think
249 that matter has not been sufficiently tried anywhere to know exactly what it is going to do. My own personal opinion is that there is going to be a dispersion, and the appearance of grease in the harbor will be very slight. I do not think that you will see perhaps not one-fifth or not one-tenth more than the grease that now comes down on the surface from these New York sewers. Nobody complains of that. I do not think anybody will complain of the grease that will be caused from the Passaic Valley sewer. Besides, it is not offensive. You have all noticed, on the ocean channel, in perfectly still waters, you will see a great track where vessels have passed before. That very small amount of grease is spread out over a large area. So, to-day, when the water is still, you can see in New York harbor a great deal of grease now, but, as I say, it is not objectionable, it causes no odors, it is not offensive, but it is a feature that will be there just as it is to-day.

I wanted to say something which I think is apropos. Manchester

is a large city in England,—it is there, quite a little distance from the ocean. It got a ship canal from the ocean so as to have ships come direct to Manchester instead of trans-shipping goods at Liverpool. Liverpool is at the mouth of the Mersey, there is a large bay,—the tidal water fluctuates about twenty feet. Manchester is a manufacturing city, also; there is lots of trade there, and the sewage proposition is a very trying one, as it has been in most of the cities in England. A Commission was appointed; they rec-
250 ommended purification. Now, most of the engineers going to Europe have visited over at Manchester, the works are very large, but I do not think that any one feels that he would like to see a work of that kind in this country. I want to say, in defence of their efforts, that they did not have money enough to do all that they intended to do at the outset; because it is expensive; but, the interesting part to me is this: I knew —, —I won't mention his name,—I will say that he is a high authority in the same profession with me in Manchester. He said to me, in the year 1900, that "it was a great mistake that we did not build a big trunk sewer and go out to sea, to Liverpool, or down in the Mersey." "Liverpool is now discharging all of her sewage into the Mersey, and nobody knows where it goes. It is not visible." But he said to me: "Don't mention that to anybody; it might cause a lot of trouble" It is a personal opinion of his. I saw him again this Summer, and I reminded him of that. I said: "How do you think now?" He said: "Why, I am publicly advocating it; as the best method of disposing of the sewage of Manchester." Now, England is ahead in sewage purification work. It is a very nice thing in small ways, small towns,—it is a nice thing where you have large areas of sand like Berlin and Paris, and a terrible thing where you have not the sand or the areas. Because this was expensive, and you cannot generally get all the money you want to do things in England. It is a practical question.

This question must be divided into three: One is hygienic;
251 the other is that of nuisance; the third is that of cost. The cost controls in most cases.

In this case, I do not think the cost controls or should control, because this Metropolitan District wants the best, whatever the cost will be, provided it is reasonable, and, while I believe that the sewage disposal of the Passaic Valley by purification will cost more, I am not prepared to say exactly how much more, and I am perfectly willing to say "Let it go at the same cost" because we do not know all these things so well that we can prognosticate exactly what it is going to cost now—while sometimes we are right in an estimate of cost, sometimes we are very far wrong,—so let me say it is the same cost, because I do not think it influences this matter at all, but the hygienic question and the nuisance question, now these two, it seems to me, must decide this. Now, the hygienic question, I see, is approaching a very satisfactory solution, although we are not prepared to give any facts, and are not prepared to build any works yet,—and it is to add something to the sewage which will destroy the pathological bacteria and other bacteria which cause disease. If we can do that, we have destroyed the cause of disease in sewage, and there

is nothing more to be said about that thing. We do not drink this water. That, really has no value in potable water,—and where you put sewage is not potable water, and I may say here, unless I am taking too much of your time, that I do not believe it is proper, in a civilized community, in the largest city of the Western
252 hemisphere to raise oysters right here in the Bay even if we purify the sewage. I don't think the oysters fit to eat, with all the street wash of the City of New York going into the Bay, and which will deposit more than sewage deposits which is mostly oxydized through being exposed to the air; and, although, as I say, all the sewage of this district, New York City included, should be purified, I do not think that the oysters would be fit to eat on this account; therefore, I have never considered seriously the expressions on the oyster question here in this harbor, nor very much the fish question, for that matter.

Just one more thing. I will say that I am by no means of the opinion that you cannot purify sewage to-day. You can; we have done it; we are doing it today, and can do it very satisfactorily, and I can give you no better proof than this: Many years ago I was in Europe, as I am frequently, and I visited the Berlin farms and the Paris farms. I have seen them since, several times: I had my boy with me, eleven years old,—I drank the effluent from both those farms; so did my boy; he is now twenty-eight years old, strong and healthy. I never for a moment doubted that the sewage was purified, because I knew exactly what took place. We have now in this country, at Framingham, Massachusetts, a plant where the sewage is purified, the effluent is pure, but the operation of the work is not wholly satisfactory,—it is intermittent, and there is a nuisance discernible for a considerable radius, which no community in this Metropolitan District would sanction.

253 I believe, as an engineer, serving a community, that his recommendation should be that which is best for a reasonable sum of money, and which will, therefore, satisfy all demands.

About the nuisance question I have not quite finished. I think I spoke about that yesterday; that, in order to prevent nuisances, you simply have to have an isolation — sufficient isolation and dilution, and that removes the nuisance, so that if you can get that dilution, you prevent your nuisance. Now, gentlemen, I have heard it said, by some sanitarians: "You are all wrong when you talk about this dilution! You cannot dilute microbes: You want to get rid of them all. You don't want to put sewage into the sea water or into water with them in it, you want to get rid of them all before." If we could follow out the effluence when it leaves the sewer outfall, as we would like to,—and possibly with the aid of money, things will be different,—but I have viewed this question of dilution from a practical point-of-view,—not from theoretical point-of-view. It occur-ed to me: It is the same as this room. We are exhaling carbonic acid gas; we are exhaling, some of us, possibly, disease germs, yet we would not think of recommending some way of attaching a pipe to our mouths and purifying the air before it was discharged into the atmosphere. This air we are in has a certain capacity for removing certain refuse matter which takes care of this pollution to

an extent; we do not know quite how much, but we have
254 found, in fact, that the air settles, becomes heavy, under circumstances such as these, with a large number of persons breathing in a more or less limited space, and we open a window, or a door, and ventilate; we know about how much air is wanted per hour, and in the same way we know how much water is necessary for the proper dilution of sewage; there, also, oxidation is taking places the same as in the air only a little slower, so that I have thought, as it was necessary to get more air, to purify the atmosphere of the room, by adding ventiation, you are solving that question. So that I have thought it was the United States way of solving this question; and the water of our towns should be utilized for street washing to a proper extent, and no further. It means taking a certain amount of filth from the city,—the surface washings; we could not purify this,—the question is, how much solid matter is left in our sewage after going through the screens. Let us ask ourselves reasonable questions like that, and then we get our opinions and information concretely.

I do not know whether I did say anything about it, but I find that most of the black muck found, of which we have heard so much about down here in the Bay, is mineral matter or organic matter slowly decomposible and which is the washings of the unbounded surfaces of this community,—there is very little of it from sewage, which has mostly been destroyed by oxydation or consumed by marine life, before it reaches the harbor.

Col. Knight: You stated yesterday something with respect
255 to the amount of water with which the Chicago sewage should be diluted, and as I remember, you said something like three and one-third cubic feet of water per thousand of population, was that it? So much per second?

Mr. Hering: Yes, sir.

Col. Knight: Then that amount of lake water to each cubic foot of sewage: Now, what would be the proportion you would think necessary, between the different effect of salt water and fresh water, necessary here?

Mr. Hering: The Chicago dilution is now, when I saw it last, early this year, 2.65 (two and sixty-five one-hundredths) cubic feet per second per thousand persons who discharged sewage into it. So that, taking it roughly, that we require four cubic feet here,—I don't know why I fixed that figure just now, but it is almost double what it is in Chicago. I do not think it is necessary to have a greater volume than in Chicago, although it is salt water, but, conveniently, let us take four cubic feet,—the chief reason why, perhaps, I might give that figure was is that New York has polluted this water already to some extent, although perhaps in different currents, along different lines of water from what those are where the Passaic Valley Sewerage Commission proposes to have the sewer discharge. And then, too, perhaps, we might also say that the decomposition is slower in salt water than it is in fresh water; so that if we take four cubic feet of this bay water per thousand per second, for one million six hundred thousand persons, which is the population provided for,

we would have six million four hundred thousand cubic feet
256 per second required to dilute the entire Passaic Valley sewage in the proportion of four cubic feet per second per thousand people, that is, six million, four hundred thousand cubic feet per second. Now, suppose the average velocity of the salt water at the worst time, that is, when the tides change, when the water seems to stand still—of course, it does not stand still for a moment, at least at certain parts of the harbor, but let us suppose the average velocity of three inches per second,—I want to say it does not stop that way, but, for argument, let us assume these three inches velocity per second, moving up or down,—(there is an under-run which continues after the tide has changed on top, and various conditions govern, differing for the water at various depths, and if you take the water altogether, in a vertical section, it is moving in the section somewhere). Now, take the average velocity at the worst time, of three inches per second, where there is the very slightest movement,—that is, we would require a cross-section of twenty-five thousand six hundred square feet. Now, as the average depth of the shaft is going to be about forty-five feet or thereabouts, that is, we require a width of discharge area of seventy by five hundred and seventy feet (Now those are only just assumptions as I have made and are of course, rudimentary,—my original figures at the moment). Now, if the velocity is six inches per second, and I am pretty well convinced that that is nearer right than three inches per second, for a few thousand feet—or for half
that distance of five hundred and seventy feet, or two hundred
257 and eighty-five feet, which is the half of the width of the dispersion area, this sewage is to be dispersed then in a current two hundred and eighty-five feet wide and forty-five feet deep as it passes from those openings and takes this sewage from perhaps several hundred openings (And I don't know how you can compare a dispersion which takes place all over the bottom in this way, with that which follows at Boston from a discharge practically at the surface, out of a pipe which runs upward, while the dispersion here is horizontally and down the slope),—then you would have somewhat the conditions as in Chicago—you would not see it anywhere, in Chicago you do not,—I mean on the surface.

Col. Knight: You leave it to the Board—you refer to leaving it to the Board to determine the amount—the size of the sedimentation basin; do you mean,—shall we infer at all from that that you do not deem a sedimentation basin necessary yourself?

Mr. Hering: No; I certainly would recommend a sedimentation basin if for no other reason than this fact, that Newark and Paterson have not the separate system and there will be a great deal of storm water and street wash going into the sewer from their combined system and that ought to be taken out. Now, after the separate system is built over the whole area, then, it seems to me, the necessity for a settling basin would largely diminish, but I am really not prepared to say now as to what I should recommend under
those circumstances, but I certainly would recommend one
258 now because of the silt that Paterson and Newark would unquestionably bring into the sewer.

Col. Knight: But you are not prepared, at this stage, to pass upon any dimensions?

Mr. Hering: No, sir; they have not been computed. We never made any assumption.

The point I would like to have settled, if I had the opportunity, is what will be, what will have to be the size of the particles that will continue to float along up the moving water of the Bay without the tendency to deposit. Of course we all know that there is a fixed relation between the weight of the particle and the velocity of the water which will keep it in suspension. Now, if course the velocity gets less sometimes, then stops then goes the other way, and very probably most of the depositing takes place at the time of least velocity; therefore, it is very likely that this is a question of adjustment more than anything else; as to what size should we want, or permit, to go out into the bay, and, when that size is determined,—or the weight I should say perhaps, not size—then we can say—we will come to know to say it is not going to deposit, or we will have a deposit of so much, when we have the velocity fixed at so much per second, it is a matter of pure arithmetics to compute, and as to the design,—what would be most agreeable to the Commission would be for you to estimate the velocity of the water in that basin, because that would enable us to compute the size of the basin; because it is difficult now to say just what size of particles will be permitted to go through so as not to occasion a deposit.

Col. Knight: Well, now, will not your screens take care of that instead of the settling basin?

Mr. Hering: No, sir; the screens take out the large floating matter.

Col. Knight: But you were speaking of screens of a millimeter opening; will large street refuse go through that?

Mr. Hering: No; well,—perhaps seventy-five per cent. might go through,—all of the very fine matter, and the most of it is the fine matter, will go through. These millimeter screens will only take out twenty-five per cent. at the most. Now, what is left? Seventy-five per cent. That goes through, and it is so fine that you must realize that it will float to a large extent,—and there is the difficulty about suggesting just exactly where you want to draw the line in that prime matter. Of course, coarse screens should be put up to keep out the coarse matter, that which would otherwise float on the top of the water and be objectionable in appearance, but the usual screens employed in the foreign sewers range from a half inch—from a half-centimeter to an inch,—and I would say that in my opinion anything less than five millimeters might cause trouble and should not keep out more sewage. And, it is a remarkable thing,—which we do not quite understand yet, unless you consider that seventy-five per cent. is very fine, in this proportion it is very fine particles of matter; of course, the chemists determine this by evaporation and other processes, and determine that this seventy-five per cent. does go out through the finest screens.

Col. Knight: But you do not say anything which helps towards

arriving at present at what should be the dimensions of the sedimentation chamber?

Mr. Hering: No, sir; not yet. I do not think we have any evidence on that subject. We have not tried to get it, because there has not been any money to do it.

Col. Knight: But you think, with money, it can be determined?

Mr. Hering: Yes, sir; I think a reasonable result can be determined.

Col. Knight: Then, would it not be a fair restriction on this permit, if issued, to require that that should be determined before the permit shall issue, being an essential part of the proposition?

Mr. Hering: I would not like to answer that question in the presence of the members of the Commission. That is a matter of judgment. I think that—as my personal opinion, as the opinion of an engineer—I would say that I should not have any hesitancy in fixing a certain amount, a certain size of settling basin, but I would admit that some might object to it, and have good grounds for so doing.

Col. Knight: You consider that it would depend on the velocity of the sewage as it passes through the basin as to how much is deposited there?

Mr. Hering: That is a very small matter—a very simple
261 matter, to make the settling basin larger or smaller; this can be determined in easy fashion after the work commences, as the settling basin and its dimensions can be determined later, one of the latest things to be built; that is a question that perhaps might be solved after these works have been perhaps half or three-fourths constructed; I should say that it might take a long time to settle that question to everybody's satisfaction; but I personally should not hesitate to go ahead and build it, and I would build it, and I would think I was doing my duty because I would believe in my work,—the results of all I have seen in Europe would go into the work, and we make those points the subject of enormous study, the most constructive points that there are I have usually tried to see. It is merely and simply a matter of judgment, not calculation or scientific certainty.

Col. Knight: But there are in certain sewage systems—you were speaking of the character of sewage at Hamburg: Do they use screens and sedimentation basins there?

Mr. Hering: They use a sedimentation basin which, if I remember rightly, is about the size of this room, and screens one inch apart——

Col. Knight: But they do use sedimentation basins?

Mr. Hering: Yes, sir; to that extent, and, let me say this,—that it is only for very large matter; the velocity of the water going
262 through that sedimentation basin is doubtless a meter a second,—between three and four feet a second; now you are not going to get any very fine deposit at that velocity,—only very large matter drops down there. By screening, the large floating matter is prevented from going out,—by sedimentation——

Col. Knight: All the sediment is screened——

Mr. Hering: The screens are located over the sedimentation basin——

Col. Knight: And it is only the matter that is caught by the screens that goes into the sedimentation chamber?

Mr. Hering: All of the floating matter is caught by the screens——

Col. Knight: But all this matter that drops as a result of the passage through the sedimentation basin would be caught on the screens?

Mr. Hering: Possibly it would; only it is far better to have it separated, so that it can be dredged out properly. At Hamburg the screens move, and whatever of the soft floating matter lodges against the screens is removed; the screen is lifted up and travels along and is then scraped off at the output into a moving trough, and that moving trough is emptied—it empties this stuff into a canal boat lying constantly alongside, then taken away; there is supposed to be a canal boat alongside all of the time. But let us suppose that a stone or a log is going through the flow into this screen chamber, you could not pick that up on the screen; therefore, there is a sedimentation basin there to hold that.

263 We have a dredge running there—opposite the works——

Col. Knight: Then there is a deposit as a result of this sewage outfall at Hamburg?

Mr. Hering: There is a channel there,—the big Hamburg-American line boats pass right over the outlet; whether the dredging is made necessary entirely by this outfall it remains to be seen; the fact is that there is a dredge running there practically all of the time, but the system of dispersion there differs entirely and is governed by different conditions of current and dilution.

Mr. Kissam: Mr. Hering, do you think there would be enough water at a point in Newark Bay, say, near the Bergen Point Light, approximately near where the Arthur Kill and the Kill van Kull and Newark Bay join,—do you think there would be enough water—water sufficient to cause the necessary oxygenation of sewage discharged in or about that point, provided the sewerage was screened and sedimented about as proposed?

Mr. Hering: That has been recommended to me, but was not considered by me.

Mr. Kissam: Well, what is the objection to it?

Mr. Hering: There is no other objection to it than that it is only a question of time when we would have to bring it out to the Bay—a question of time when we would have to bring that up. Now, in this proposition, just what composition is discharged into the middle of the Bay is significant, and is as recommended, but there you can get a discharge at the bottom of the Bay, and I think you

364 cannot get a discharge into the bottom of the Narrows, but I think the dilution would be sufficient to render it in-occuous, at the points referred to.

Mr. Kissam: And that still remains true after twenty-five years?

Mr. Hering: No.

Mr. Kissam: Well, how long, in your judgment, would it remain?

Mr. Hering: That is very difficult; I have in my office——

Mr. Kissam: Well, how long do you think?

Mr. Hering: I have calculations on that subject. I know it has been gone through——

Mr. Kissam: You did consider it?

Mr. Hering: Yes, sir; it is only a question of a few years, and then you will have to go somewhere else, which necessarily involves the loss of money and time. I would like to say, in passing, if you will permit me, that the future of these matters is a factor that should never be lost sight of by an engineer advising the investment of many millions of dollars. I do not think that this sewer is the end of things. There is going to come a time when something else will have to be done with that sewage just as with the New York sewage. Where can you do anything in this great Metropolitan District? There is only one place, and that is below the Narrows somewhere.

Mr. Kissam: Well, is not the alternative remedy the sprinkler system you suggested——

265 Mr. Hering: I am not prepared to say what should be done with the New York sewage——

Mr. Kissam: I mean the City of Newark——

Mr. Hering: The alternate is a sprinkler system; yes, sir.

Mr. Kissam: That would be entirely feasible?

Mr. Hering: Yes, sir; from an engineering point of view.

Mr. Kissam: What would be the objection to that?

Mr. Hering: The objection would be this, in my opinion,—not as an engineer. You have to have a considerable area around this plant to protect the outside from the odors coming from it, because the sprinkler system causes considerable odor. Now, I am not so certain but the time will come when we will house some of the sprinkling filters; we have housed some of large dimensions that way. You will have to have about one hundred acres for this sprinkler-filter,—something like that. You want to have plenty of land around it, to prevent the odor from becoming offensive, and I think that half the section lying below the Hackensack, or something, I forgot the name, would have to be devoted to it. Well, now, that part of Newark and Hackensack Meadows is, I believe, going to be built up and populated as soon as some method has been found to fill it or to drain it and get it ready to produce something and return some revenue for its position—it has a very very attractive position for many purposes, right between Newark and New

266 York, and this sewage disposal system would be a detriment to the development of that whole area, and is so considered in Europe. It is not a place where you go with preference,—you go away from them with preference, although I admit that there are places along these sewage disposal grounds where people live, but you find them nearly always alone, in intermediate districts where there are no conveyances, or practically none, and I do not know of any of these larger processes for purifying sewage where people live up close.

Mr. Kissam: Have you considered the Newark Meadows at or near Elizabeth?

Mr. Hering: That is just where—that is the locality I was referring to——

Mr. Kissam: You said Newark——

Mr. Hering: Well, that is just where such a plant would have to be located——

Mr. Kissam: Have you gone over that territory?

Mr. Hering: Yes, sir.

Mr. Kissam: It has no buildings? Is barren land?

Mr. Hering: Yes, sir.

Mr. Kissam: It is an absolutely barren territory, is it not?

Mr. Hering: Yes, sir.

Mr. Kissam: Ranging for miles from the Bayonne peninsula, off for several miles?

Mr. Hering: Yes, sir.

267 Mr. Kissam: Now, the point I wish to make is this: I represent the City of Orange, and, of course, the element of expense is very important to us; the cost of that deep tunnel sewer will be about twelve millions of dollars, and the cost to us will be about six million dollars, or about one-half of the whole estimated cost of the entire project. Now, the point I make is that there is no necessity for the granting of this application, because it is entirely feasible to put in a sprinkler system on the Newark Meadows which can entirely take care of this situation, the only objection to that, is the odor, and the possibility of being a detriment to the building up of those meadows in the future.

Now, we do not, in the City of Orange, object to improvements; we stand prepared to do everything we can to clear the Passaic and make the Passaic River a beautiful strea-, once more, but we do not want to be put in the position that where these Commissioners have wasted a large amount of our money, to be compelled in the course of a year's time or in the course of a few years, in the course of a generation, or fifteen or twenty years, to pay this thing all over again, because then it would be necessary to establish a sprinkler system because of the condition of New York harbor. If New York harbor is to become so vile, in the course of a reasonable time, that it will cause disease, be offensive, become filled up, and the people will have to stop sewage into New York harbor, it seems to me very unfair to us to tap the smaller towns to a point where it means almost absolute
268 penury in order to experiment with this sewerage disposition system into deep water, which is entirely unnecessary,—I mean when they admit that the sprinkler system is entirely feasible. The point I make is that it is not necessary because it is possible to dispose of all this question by erecting the sprinkler plant.

Dr. Brush: The hour is late, and I do not wish to detain you, but, speaking for the Booklyn League, which is composed of over a thousand of our business and professional gentlemen of Brooklyn, I appear to oppose this proposition for the reason that the added pollution of this proposed sewer to the waters of this Bay will simply add to the difficulties which have now been demonstrated by the examina-

tions of the Merchants' Association which, I suppose, are before you,—if they are not they will be, in a pamphlet which shows that pollution by sewage in the waters of New York Bay, and while the waters are not potable or drinkable as with Boston, at the same time there are matters deposited that are along the surface, and that is a question that has not been spoken of at all here to-day, or at all so far as I know—I unfortunately could not stay yesterday and lost a good deal of that which has been said, and if it has not been said, I want to say it,—we know that they have demonstrated that the intestinal diseases during the period of floods are very largely increased in the localities where this deposit is upon the posts and piers of the wharves of this City, and they have traced it to this: flies
269 alighting upon the posts and then upon other materials and thence taken into the stomachs of children and adults as well.

Now, we protest against the pollution of the waters of this Bay any further, with any other materials that has not the bacteria destroyed,—any pollution, and it seems to me that in view of what science has revealed to us in the twentieth century, in view of that, it would be a shame and a disgrace to empty into the waters of New York Bay six hundred thousand gallons or six thousand gallons in which the bacteria of typhoid germs, germs of tuberculosis and all of the forms of disease that we know are infectious and perhaps contagious and especially infectious are contained.

And that is the ground upon which we base our opposition. It is on humanitarian grounds; it is not a question of taste and sentiment; it is not a question of smell; it is not a question of what we can see. Our worst enemies you cannot smell or see; these germs are hidden, and they attack us in points where we least expect it, and, therefore, I say that we should not consider for a moment the granting of a request which will enable any one whether in New York State or in the State of New Jeresey, to pour more pollution into the waters of this Bay. We are trying now, and have been trying for the last year or two to get legislation at Albany which will prevent any further emptying of sewage into the waters of this Bay, and we are studying that question with a view to trying to get disposal plants which will obviate the necessity for that, which will
270 make it necessary for the City of New York in the future to entirely re-construct or re-arrange her sewage system—and it certainly ought to be done in the interests of all; and, therefore, I am here to say that we oppose the granting of this permit.

The Chairman: The hour of half-past one having arrived, a recess will be taken until two o'clock.

(After Recess.)

The Chairman: Gentlemen, if you will come to order, this hearing will be resumed. The Board is prepared to hear anything further on the subject.

Mr. Harrison: There has been a considerable discussion here, and a number of statements made that may lead the Board to believe that the proper thing to be done in this Metropolitan District is to

undertake the construction of a sewage disposal plant. That would mean, I presume, in the opinion of the gentlemen making this statement, of the whole Metropolitan District in and about the City of New York; that we were to commence to establish a plant to take care of all this sewage in a sewage disposal plant, and, when I say the whole Metropolitan District, I would mean the whole five or six million people who now drain into the harbor of New York. That statement is a most extreme one. I know there are engineers in the profession who believe that all sewage should be passed through treatment and the effluence should be more or less pure. Some even go as far as to say that the effluent should be fixed so that it could be used as drinking water,—and they are very like some doc-
271 tors. I know doctors who say that the proper thing to do with a child is to remove his appendix, that it is a bad thing to have and it is better to have it removed at once, rather than after it may have caused trouble later on in life.

The way the great conservative body of engineers who have studied the sewage question think, and I am one of those, and I think the great body of conservative men look at it, and I believe the officials of the City of New York look at it, is this way: that the way of New York, the Hudson river, and the great balance of the topographical features of this Community, this territory here, the East River, and so on, where the large amount of tidal inflow through it and the periodically large, enormous flow down the river means the best relief for the City of New York and for this community. Now I wonder if it is realized that in order to provide a sewage disposal plant and the necessary modifications in sewers, etc., it would require a capitalization of two hundred and fifty million dollars, to complete it, for the City of New York alone, would require the investment of two hundred and fifty million dollars. The gentlemen here representing the different boards here, and representing the different parts of the City of New York can represent whether the City of New York is prepared for some years to go into this thing, from a financial standpoint, and, when you do this, you cut yourselves loose from the natural advantages which have been yours and would be yours for all time. We think that it is proved by the evidence submitted to the Governor,
272 and to the City of New York by the Pollution Commission, and also can be proved by their statements that at the present time the great body of water in the harbor of New York—of which we claim to be a part—which we are—we claim to be a part of it,—of this Metropolitan District naturally draining into the harbor,—that the great body of water in the harbor of New York is practically unpolluted. When I say unpolluted, I mean it is not fit for drinking water,—it is not potable, but I mean that the quality of the water is practically standard,—of the standard accepted all over the world for great commercial harbors,—practically unpolluted.

I do not think that any of this Board, gentlemen, can find any harbor in the world—with a community as large as this draining into it, with water that is as pure, as clean, as the water of the harbor

of New York. You won't find it in London, Rotterdam, Amsterdam, Genoa, Venice, or any of the great commercial cities.

Now, generally, I believe that all of these cases should be treated by themselves,—these cases of sewage disposal. We believe that inland developments, such as the city of Columbus, Ohio, and a number of Pennsylvania towns, and inland towns and localities in general, where the surface sewage has to be gotten rid of by some means so that the water is not carried into a stream thereafter to be used for drinking purposes,—that some method should be taken to treat it. But, we believe that the system—that where a community has a great purifying element right at its doors, that
273 natural right of having a large body of water, capable of diluting the sewage of a community and rendering it inoccuous, have the right to use a proper, economical method of sewage disposal, and I think that is the idea of all engineers who are not specialists in some peculiar line.

Now, there is no doubt in the minds of this Commission, nor in the minds of any of those engineers who have studied this subject, that the harbor of New York, with the water we have got here, will take care of the needs of from twenty upwards millions more people,—of the sewage of those people, more than at present drain into it, and the New York Bay Pollution Commission nor anybody else ever said anything to the contrary. They all agree that at some indeterminate time ahead New York will reach a point where you will have to look out for the harbor, but that time will not come until the population draining into the harbor will have reached at least twenty million, and, of course, when I say that it will care for the sewage of twenty million, I mean if it is properly distributed so that the sewage is not locked up in estuaries and stacked up in the slips and piers, but goes into the harbor freely distributed. And this same condition of affairs has been considered.

Take the Boston case, which we hope to improve upon: In Boston, the sewage comes out of the sewers at the end of a pipe, a large pipe, in one mass. Now, the rapidity with which that sewage is oxydized, and the offensive characteristics taken care of, depends upon the quickness of dispersal, as the air cannot reach the solid
274 column of sewage discharging at the single outlet; that condition is one which we propose to change practically by means of our plans for dispersion of the sewage at the outfall. The same as when you put a lump of sugar into water; the lump dissolves slowly, and remains in the water a considerable time, but if you put the same quantity of sugar in the form of powdered sugar, into the water, it is gone quickly. That is our principle for our work.

Now, we come to the disposal works. As I say, where things are such that it is impossible to get an outlet, those towns labor under that disadvantage: Why should they wish to put this great community to that disadvantage, when they have the water here, and there is no question about it, nobody claims or has ever complained of the existence of a nuisance in the waters of New York; and these gentlemen have often, no doubt, noticed the presence of a nuisance

alongside the ferry slips, at low water,—which I have seen at Courtlandt Street, and at 34th Street, and at 42nd Street, and, especially there alongside the gas houses; we all know that Newtown Creek is another Passaic; and it is no wonder, with the sewer system in vogue; that is the point we want to reach—this sewage should not be brought into the pierheads, but should be so discharged into the tidal waters as to mix it and disperse it with the enormous quantity of water we have got here. In Boston they have done it, and we improve, in our proposition, upon the Boston methods, and I do not understand at the Boston works that they propose to give it up.

275 Here we have the State of Massachusetts, which has made more advancement in the methods of sewage disposal work than any in the world—in this country at least, and they have gone into extensive experiments above all others, and yet they adopted this plan of general ocean disposal,—they are extending that plant,—not thinking of giving it up.

You have the City of Baltimore with a disposal plant. Why? Because the lifeblood of the City of Baltimore was in Chesapeake Bay and the oyster beds and fields; they believed, and they were afraid that if they disposed of sewage in the Chesapeake Bay, and there should be a general knowledge of it, possibly that business would be ruined. That don't apply here. The gentleman talked about the oyster fields on the Jersey shore; well, I have lived around in this community, on the Jersey shores, for forty years, and we have cultivated other things than oysters on the Jersey shores.

Another of the points I have to speak about. I do not know, and I do not believe anybody knows of a sewage disposal plant anywhere that is absolutely satisfactory. We have gone into it quite extensively in New Jersey in some of the suburban towns. We started rather early in it. The town of East Orange started in over twenty years ago, and the engineer who put in that plant for East Orange wrote a very able paper on the subject after it was finished, and it was quoted as a very lucid statement of the case, giving a very great deal of enlightenment on the subject of sewage

276 disposal, and it was generally believed to be a successful plant. Recently, in conversation with a resident of that city, he said they were going to give it up; that he has not seen it in years——

Mr. Child: It has been abandoned.

Mr. Harrison: So there, you may believe, they have very little faith in sewage disposal plants of whatever kind. This is particularly true with regard to the system of disposal that was adopted for the town of Summit. I lived in Summit for two or three Summers, while the plant was working, and whenever the wind was in the right direction, the whole of Summit knew that they had a sewage disposal plant, and whenever the wind was in the other direction, the neighboring towns had the same knowledge forced on them. I am consulting engineer to the East Jersey Water Company, the corporation which supplies Jersey City with water, and I know that several times we have had to notify Summit that—

although their plant was twenty-five miles up the river,—the raw sewage was coming down to the pump works at our plant.

I had occasion, not long ago, to look into the plant at Richfield, and there they have a plant on a gigantic scale, complete in all respects, a plant built by engineers who stand pretty high in State of New Jersey and the City of New York, and at this plant they had put in contact beds and septic tanks, and then ran the effluent into a creek through a concrete channel, and if you will go up there to-day you will find the channel all cut up, the chan-
277 nel stone piled up on one side, and the raw sewage running through on one side into the creek; the concrete beds did not work as they should.

I heard a little while ago, when I looked into the broad irrigation plants of Westfield, the water worked its way over a portion of Westfield, and to take care of that they went over where there was more territory; that plant, as you will admit, is a well-built plant, but that plant should be at the effluence, which we would have no objection to, putting the effluent into reservoirs, it was found that the effluence did contain an odor, which might have been anticipated, but we did not expect to find at a distance of two and a half miles from the effluence, actual effluent from that sewage plant discharging into the Rahway river at tide water.

Now, there are also several plants at institutions, I should say,—at Morris Plains, at the Normal School, and at small institutions; there you probably have a million gallons or less than a million gallons; those plants work; that is, they do very well, but when you come to figure up the cost,—they are all in the hands of skilled men, who take care of the institutions, stay there, live there on the place, and always watch carefully about the cost, yet the cost per million is prohibitory, when you have several million gallons a day, the cost becomes practically prohibitory, and when I say prohibitory, I mean reasonably prohibitory. It may cost the City of New York a great deal to take care of its sewage under such a system,
278 but that would not mean so much to so thickly populated a community, the same being true of Newark, but when you get up into the State, to the towns and cities right up on the Delaware, where they have to use the water for drinking purposes, and must dispose of the sewage, many of them cannot afford to go to that expense.

Moreover, abroad, you find disposal plants all over England, and I have never been near one yet, never been around one of those disposal plants in Summer but what you can tell there is a disposal plant there. Those plants always send up that sweetish-sour smell of sewage, at all times during the Summer. And we get knowledge of them the same way in the continental plants. The gentleman who spoke of the Berlin plant the other day said that it does not smell there; that may be the case, but it is a fact that nobody lives there.

Then, another thing, the effluents from these plants are not what these gentlemen think they are. They are not fit to drink. They simply look pure, and are very apt to contain a portion of the sew-

age, and do as a usual thing, they are entirely clear, it is true, but not fit to drink.

One thing you want to remember, and a very important point in this case, I think, and which I forgot to mention here in my discussion yesterday, and it is, when you take the sewage out of the Passaic River and out of Newark Bay that will give you about one-
eighth of the flow of the Bay—the flow of the Narrows, in
279 pure water. At the present time the waters of Newark Bay and the Passaic River are almost totally devoid of oxygen, and have not any in Summer, but when we take those waters running through the Narrows into Newark Bay, you abstract a portion of the oxygen which is in the Bay; but when we take the sewage out, you will have one-eighth of the ebb flow,—the flow of the Hackensack is about one-eighth of the Narrows flow, you will find one-eighth of the Narrows flow coming in there with practically pure water, with plenty of oxygen in it, ready to help to reinforce the oxygen of New York Bay and thus oxydizing the sewage as it goes into the Bay.

Now, I think, and our point is that though at first blush it seems to be quite a proposition to ask permission to do what we are asking to do, yet, any New Yorker, who thinks over the subject and comes to understand it, will ask himself why they should be at present opposed to this plant? We will take the sewage out of the Bay, and clean it for you, and in doing that, we are taking from New York a right worth two or three hundred million dollars, and now it may be said that when the population of New York or of this Metropolitan District draining into the Bay shall reach twenty millions in all this section, you will have to take care of it, but what engineer here will be fool enough to say what methods there will be for the disposal of sewage at the time when the population of this section reaches twenty millions. We may be turning sewage into whiskey or alcohol then.

Another thing, how do we know that there will be a poula-
280 tion of twenty million in one congested mass? If this is to be a city of twenty million population, just try to imagine what the effect will be of four times the population in the crowded streets of New York; how would you supply them with food, where would you get the railroads to serve them? All of these things must be considered. So, it is doubtful, a very doubtful thing, and no one credits this opinion as to what New York is going to be in twenty years. We all know, and you gentlemen know, that in 1866, a gentleman then at the head of your Health Department, wrote a report in which he said that New York harbor was filling up, and he asked that a report be made after a survey of the conditions; and the result of that report was—the gentleman believed it was filling with sewage,—he thought that sewage was having a great deal to do with it, but the fact was that the report showed that a number of individual contractors who were dredging in the harbor, who dredged around New York, were dumping their dredgings on the Jersey flats; they dumped it on the Flats without any bulkheads; that dredging was running down towards the channel, and a survey was made which showed along the Jersey Flats dark lines sixteen to twenty-

five feet below high water at the large channel, for about two hundred feet, and of course in the Flats it don't take very much filling to bring in two hundred feet. Then there was a great time made about it, everybody said that the harbor was filling up, particularly this Health Commissioner, and he said they would not be able to get the Great Eastern in,—the "Great Eastern" was the big
281 boat of those days. The report was made out and a regulation made, which is that regulation which applies to-day, that no more filling should be put in except inside of bulkheads; the regulation being enforced, there was a large improvement as after that all this filling was stopped. Now, this brings us to the question of deposit. I have a very intimate connection with the bottom of New York Bay, especially on the Jersey side. I made the first investigation for the present Pennsylvania improvement,—the borings and soundings. I have made very numerous investigations since then for railroads with regard to terminal facilities; I am very familiar with the depths of water, and have been familiar for the last thirty years, during the time that New York has been growing from a population of five hundred thousand to four million and up, and am acquainted with the theories of this flowing mud and its deposit, having made soundings and done general contracting work on the Jersey shores, and I do not think that there is any change in the amount of deposit, one way or another. If you will examine the Coast Survey Report of 1865 and their charts, you will find that to be so except where artificially filled in. Whenever I have had occasion to examine the bottom, this has been my experience, and on an occasion where I examined I found the river four feet deeper, that is, from Jones street North, from our dock, North. I believe the channel is about that much deeper, or more. Of course, that would be natural as a result of bringing in the bulkhead lines.
282 I have consulted with engineers on this point, and they are agreed. I do not believe, with the sewerage in New York Bay, you can change the arrangement of the Hudson River or New York Bay by the deposit of sewage; the river will take care of this. I also took this point into consideration: That the enormous flow of the torrent of the Hudson in the Spring, as you and I have seen it running ebb away down below the Central Railroad Bridge, running full of silt and mud and muck the result of the Winter's accumulation in the ice-bound waters from the whole of New York, which makes a deposit when it goes out beyond the Bay, after being brought down through the gorge of the river, and this may likely leave a deposit in a manner practically as it flows, just as has been going on in that locality for many years.

Now I understand what has been said—and I do not want to let it be understood that the engineers of this Commission do not deprecate the conditions of articial disposition of sewage, as to conclusions from cost or taste. One of the most important factors entering into this matter is as to the business side, the side of commerce, the economical, proper sanitary welfare of the public and, taking everything into consideration the engineers of this Commission have concluded that the proposition involving the least risk, is the allowing of that sewage to pass into the water, under the conditions outlined. Now,

there is one point,—they seem to have an idea here that we are relying entirely on currents. Now, we do not. If you put one
283 part of sewage into fifty parts of ordinarily clear and pure water, water with the natural amount of oxygen in it, whether salt or fresh water, and fresh sewage, the sewage so put in is inoccuous, in salt water in a tank, in sea water, or in anything else. That point is of importance to us; of necessity,—the currents of usefulness,—the presence of the currents is advantageous as it involves the presence of a large body of fresh water and of clean water, and we can arrange our sewage for passing through it. As Mr. Hering told you it is our purpose to have the sewage go out slowly; we can regulate it as it goes through our works. Boston cannot. Boston sends it out by gravity alone, without control. With us, in our sustem, it is only a matter of a little more coal to get a greater head on, or a little less coal and a slower head. That is arranged by the pumps. We let it go out as we want it to go, and we mix it or carry it in the diluting water. Now, when you get one part of that sewage into fifty parts of New York water, it don't go five hundred feet away before it is imperceptible, totally passed out of sight and dispersed. In all the investigations made by Great Britain of the sludge from the London sewers as deposited in the River Thames; they take their sludge in large boatloads, take it down the estuary of the Thames to tide—deep water; when it is down twenty miles, they again throw it overboard, steam around in the same place, opening gates in the lower part of the boat, and allow the sludge to drop out. In ten to fifteen minutes, or in a very short time after that sludge is dropped
284 it is impossible to detect that any sludge has been put into the water, so far as the closest bacteriological and chemical tests can determine; it is gone. They steam around; maybe let the boat go down the river and special tests show that it has been taken up by the oxygen in the water, by the bacteria,—taken up by the small animalculæ around there; and there are a great many around there, it is a great place for fishing, any number of people always fishing around in that locality. That is what we think is the case here with our proposition in New York Bay, and we think that will last until fifteen or twenty million people populate this district, and then, by that time, the engineers, I think will take care of it, and it is ridicuous folly for the engineers of today to say what they are going to do with New York sewage twenty years from now. You might as well have asked the engineers the plans of the Hudson tunnel thirty years ago; they never would have been able to build it according to those plans,—and in fact they could not do it with the plans then made for that tunnel; and when I talk about plans of thirty years ago, for that work, I am talking from experience, as I have been closely connected with the railroads and with terminal matters of the Pennsylvania Railroad, and with the terminal affairs of other railroads, for the last thirty years, and when I first took those matters up, we thought that it was foolish to undertake to build the tunnel, we thought that there would never be a time when the needs of the country would require it; nobody ever thought of

dredging to a depth of thirty feet in the lower Bay, and
285 equally unthought of was the building of such a structure as the Pennsylvania Railroad is building today, and which is absolutely necessary for terminal facilities. I then made a report on the subject, and when it was put in, was practically concurred in by all of the Pennsylvania Railroad engineers; it was folly, we thought, to think that they would ever have such a railroad terminal. Then, I may say, in those days in considering dredging matters, we figured on forty or fifty cents a yard for dredging, and as high as Two dollars a cubic yard for filling; and now, with the improvements in mechanism for this work you know how the methods and costs have been modified: We dredge now for ten cents a cubic yard, and we get all the fill in we want for twenty cents a cubic yard; so that work which would then have cost upwards of twenty thousand dollars is now easily done for Five thousand dollars.

And, so I say, when these gentlemen talk about the waters of the harbor becoming a nuisance, or becoming clogged up, if we will measure the waters of New York Bay in the light of this big project that has been undertaken by the Pennsylvania Railroad, with reference to what was thought would be the case, and if we look at this matter on a large, broad scale, there is no reason why the great advantages of New York should be, or be attempted to be, changed from what we have learned they are, and it would really be a great mistake in a great community like this, where the first question is: Can you dispose of sewage by mixing it with water? Can you arrange its dispersion so as not to create a nuisance? and,
286 secondly, If you can, don't think of anything else.

Dr. Soper: Representing the Metropolitan Sewerage Commission, I read a statement yesterday in which the opinion of the Metropolitan Sewerage Commission was expressed, opposed to the Passaic Valley project.

After listening to all of the statements that have been made since then, I do not think that I should want to change the wording of that statement. It represents, of course, not my own views, but those of the five members of the Metropolitan Commission, all of whom have given this subject considerable study.

At the same time, in the proceedings which followed my remarks, my name has been mentioned several times, and some of the statements that I made have been criticized. For one thing, the name of Mr. Allen Hazen has been brought into this discussion as having contributed to the discussion of a paper which I read before the Sanitary reception of the Boston Society of Civil Engineers.

I should like to have Mr. Hazen's complete discussion before you, and, if possible, the discussions of Mr. Harry Clark, Chemist of the Massachusetts State Board of Health, and Mr. Coney, the Engineer of the Massachusetts State Board of Health. Mr. Hazen's remarks, if I remember them—I have not seen the discussion of the paper now for some time, referred to the inadequacy of the data upon which he based his discussion, and recommended that the studies

which were being discussed be made very much more full
287 and complete; those studies are now being made much more full and complete. The Metropolitan Commission exists for that purpose.

Mr. Harry Clark's discussion, if I remember it correctly, shows the danger of polluting tidal estuaries in the direction of injuring the purity of oysters and shell-fish. That point has been referred to here, in these statements that have been made before your Board.

Briefly: It may be unnecessary for me to extend them. It has not been brought out, however, that, within the limits of New York City, there are annually produced upwards of five hundred thousand bushels of oysters. They are marketed here and are eaten, for the most part, without cooking. Cases of typhoid fever have been accounted for, just as reliably, I think, as typhoid can well be traced, to the eating of some of those oysters; oysters cultivated and grown in the waters of New York. According to the latest statistics that I have been able to collect, there are grown annually about seventy thousand bushels (?) seven (?)* thousand bushels of oysters in upper New York Bay. This used to be a famous oyster-producing ground.

Mr. Hazen's discussion of my paper before the Boston Society of Civil Engineers, in common with the opinions of many other engineers with respect to the diluting-power of the waters of New York harbor for sewage, were based upon the assumption that all of the water of the harbor was available for diluting and assimilating
the sewage, and, apparently, upon the assumption that that
288 water was immediately available for diluting and assimilating the sewage.

It has been demonstrated, and fragments of the evidence have been put before your Board, that sewage discharged into the waters of New York harbor does not immediately become dispersed. It has been stated that the sewage floats about upon the surface to a very considerable extent. We should, then, consider, not the tidal volume of water,—not the total volume of water which lies there in the basin of the harbor and floats in and out,—the quantity which floats in and out with the tide when the tidal prism does, as available water for diluting and assimilating sewage, but its surface area, multiplied by the certain depth—the exact depth we do not know as yet—which is all of that volume of water so available.

One of the most difficult problems which we are studying to-day in the Metropolitan Sewerage Commission, is how sewage discharged into these waters can be so dispersed as to become inoffensive before it is distributed.

With regard to this matter I would invite the consideration of your Board to a report of the State Board of Health of Massachusetts upon the discharge of sewage into Boston harbor, dated 1900. You will find there evidence in the form of an official report, and a map, to which I would especially invite your attention—considerable evidence upon the effects of the outfalls of the Boston drainage, and

*(Stenographer: Probably seven.)

modern drainage system—also some facts, one of which I will briefly read:

289 (Reading.)

"At the outlet in our Deer Island Beacon, which is four and two-thirds miles from Long Wharf in Boston, in the windfall East of the main ship channel, sewage from the North Metropolitan District is allowed to discharge as it comes, in all stages of the tide. The quantity of sewage discharged in twenty-four hours now reaches about fifty million gallons, and this quantity, while distinctly visible along the Northerly edge of the channel for a half mile towards the City, on the incoming tide, and towards the sea, on the outgoing tide, gradually becomes less distinct at greater distances from the outlet, and disappears entirely within a distance of one and a quarter miles."

The material is distinctly visible and described as "offensive" in this report; such material it is as would not be retained by screens nor by settling basins; it is material which floats upon the surface.

That is a sample or type of the local nuisances which exist to some extent in New York harbor to-day, and which we believe would very probably result from the discharge of the Passaic Valley sewerage under the plans proposed.

With regard to the exhibit of bottled experiments that I offered you—Mr. Hering brought up the question whether solid matters did deposit more rapidly in sea water or fresh water. I offered that exhibit to show you, in a graphic way that sewage sludged or deposited more rapidly in sea water than in fresh water. The experiment may be easily repeated by any one; it was done
290 in this way: Sewage sludge was taken, in equal quantities, and put into each of two bottles; one bottle was then filled with sea water and the other with fresh land water; the bottles were allowed to stand; at the end of the periods of time indicated on the photograph cards the effects, which can be noted, were photographed.

Mr. Hering has indicated that Mr. Fowler, connected—Dr. Fowler, connected with the Manchester Sewage Disposal Works, has, I think, an opposite view. I would refer your Board, for substantiation of what I was saying, to an appendix,—appendix number eleven, of the report of Mr. John Sylvester Freemen to the Committee on the Charles River Dam, Boston, 1903: I can briefly say that there are photographs reproduced there which illustrate, and in more exhaustive manner, and with various changes, what my photographs showed you yesterday, and I would ask permission to read this brief statement, from page 286:

"In the course of this investigation, and in connection with observations of the appearance of the river at present during times of storm, certain experiments have been made upon the comparative degree of rapidity with which bodies of turbid fresh water and turbid salt water clear themselves. It has been shown very clearly that salt water acts like a precipitant, especially if the turbidity is caused to some extent by bodies such as are present in sewage * * *

This is true if the matter causing turbidity is well mixed with the water. * * * If turbid fresh water is placed above salt water, the turbidity will disappear slowly when the water is quiet.
291 This effect is shown by the photographs;" and so on.

Those are documents which are well worth very full consideration.

With respect to the kind of turbidity produced by my experiments, and with these (indicating book previously quoted from), I would ask you to consider that the solid matters are not such as would be removed by screening, nor by simple sedimentation for the brief period which Mr. Hering has indicated, so far as we understand his meaning.

The Mercey and Elbe rivers have been described as places where quantities of sewage were being disposed of without injurious consequence,—in fact, without being visible. I would ask you to consider that they are both turbid rivers, particularly the Elbe, and that experiments have been made, and analyses of the Elbe, which show that, although the sewage is discharged only on the outgoing tide, evidences of it are clearly discoverable at the water works of the city considerably above stream.

It is not a question alone of producing wholesale nuisances throughout these harbors that objection is made to increasing the amount of sewage pollution. The question of extensive local nuisances is one of very considerable import.

It has been urged that cost—Mr. Hering said, that cost should not control in this matter—The Metropolitan Sewerage Commission would urge that you give considerable weight to that point.
292 If there is no other reason than cost—if there is any other reason than cost to prevent the purification of the sewage or the handling of it in other ways without discharging it in the raw condition proposed, we believe—we do not appreciate it.

We believe that the disposal of the sewage under water in the manner proposed is in the nature of an experiment, and, although we are not prepared to say to what extent the harbors and channels will be silted, nor to what extent precisely other injuries may come to navigation or to the public health, we believe that safety requires that no question of doubt be allowed to attach to that matter.

I would also ask you to consider that there is a difference between the discharge of the sewage at the Passaic outfall and into rivers, in this respect at least; that, whereas the discharge of sewage into a stream running in one direction, may load that stream with, for the time, we will say, uniformity,—with a current such as flows backward and forward in New York bay, the water would get a double dose of sewage, or, at least, some of it would. The current which flowed up stream towards the end of the tide would return and get its second dose on its way towards the sea.

Mr. Hering, and I think perhaps others, have suggested that experiments be made to give us more light upon this uncertain question of diffusion. We know very little about the phenomena of diffusion,—of sewage in salt water particularly. The Metropolitan

Commission considers that a heavy burden rests upon it for
293 ascertaining some of those essential phenomena. If it is admitted that we know little now about those matters, we think there is more reason for considering that uncertainties attach to the projects of discharging the sewage in accordance with the proposed plans of the Passaic Valley Sewerage Commission.

Mr. Sandford: Gentlemen: I am not here under pay. I am not here by invitation of the Sewerage Commission. I am not here by invitation of New York City. I have a diversity of interests that are affected in various ways by this question of sewage. In the first place, I am the owner of three different tracts of land on the Passaic River. The sewer, if built, passes through lands owned by me for seven hundred and fifty or eight hundred feet. I am in the contracting business, and have vessels and boats in the Passaic River. I am the president of the New York Lighterage Company of the City of New York; we have vessels here. I also have interests in coast-wise vessels.

Now, it would seem to me—I have heard these discussions from the beginning—it would seem to me that the gentlemen—that a commission of the City of New York and one from New Jersey should get together on this matter and determine what is best at the present time and for the future,—not forever.

We know, about twenty odd years ago,—not over twenty-five years ago, the City of Newark spent a good deal of money building a sewer down into Newark Bay. That don't answer the purposes to-day. Now, they are asking the others to join with them and make a better arrangement. Now, this may be good for ten
294 or twenty years and after that we may need something else.

Now, I have heard Mr. Eastwood, of Belleville. I own property there myself. He told you about the houses being affected,—the paint on the houses. The gentlemen here the other day told you how the paint was affected on the boats. Now, I don't want to have this matter cured up in the Passaic River, if it is going to come out here and take the paint off of my boats here. Now, that is one of the conditions.

Now, twenty years ago I lived in a residence on the Passaic river at Belleville where we pumped the water out of that river and used it in our homes. Eighteen years ago, about, the gentleman—I am sorry that gentleman from Orange is not here—Orange is a progressive city—they built, eighteen years ago a sewer, and their receiving chamber is in the City of Newark. Under the laws under which that was built—and I know particularly about it because I was a bidder on this work—they were to store this sewage in this receiving chamber and let it out when the tide was ebbing,—but they have gone ahead of that. They have progressed!! They have abandoned the Moon Island plant and have gone over to the "Deer Island" plant: they let that out one day, and then lost the key and have never been able to close the gate since. I left my home (when that sewer was being built, I moved to Newark while it was being built) at Belleville. I live over in Orange to-day. The argument
295 was: There was very little building below there, and if they let it out on the ebb tide there would be few people affected

thereby. But, they did the other thing. They allowed it to flow at all times of the tide, and, therefore, they are one of the chief polluters of the Passaic River. At Belleville, the very town that they are polluting to-day, I own three houses on the river, where I have tight cess pools and tight water-closets, and it costs me Thirty dollars every little while to have them cleaned out; but this gentleman from Orange, this progressive man,—he puts his filth down there, and it floats by and down the river before those houses.

I don't believe these gentlemen have any objection whatever to those gentlemen of Orange having a filtering plant such as that which he suggested, on the Meadows,—we have one now in Newark, and the people have had them before a jury a number of times because of the way they take care of that. If they want one, let them build a system out of the city of Newark; we will get along without them. But let them put their filtering plant—their filtering basin up in their own territory.

Now, gentlemen, we are all identified in some way or another. I have, among other interests, an interest in the New York Horse Manure Company, that takes the manure off the streets of this city. We own our own floats; we own our own dumps, our own storage land. We take the manure every day from this city and take it out of your jurisdiction and over into New Jersey; we stored it on the Hackensack river up to about one and a half years or two
296 years ago. You had a smelling committee over here in New York which discovered that heap of manure, and one of the arguments they used was that the Pennsylvania had cars stop near that manure heap and that the flies got into those cars and were carried to New York. They didn't think anything about all we carried out on those manure cars. It was the flies that left the manure cars and got into the other cars. Now, what is the consequence? We were driven to the woods! We had to go out on the Rock Hill Branch of the Pennsylvania Railroad and buy a piece of land; here we were using land over there that belonged to the railroad company and didn't pay a cent of rent for it; we have had to put in a great system of tracks for it, and all of that is of vital importance to me because, on account of the great expense this year we have not been able to pay a dividend.

Now, gentlemen, we have all got to help each other a little bit in this matter. As I told you, I don't want this sewage to come down here and in place of taking the paint off of my Belleville houses, to take the paint off of my boats, if possible; but when you go up there and see that little stream of water and see the immense mass of filth that it is expected to carry,—no larger until it goes from Passaic until it gets to Newark, and the water supplies have cut off the entire flow of the river, and all we have to-day to take care of this sewage is simply the water that flows in from Newark Bay. That is all that we have to take care of all that sewage.

There are so many things to be said, gentlemen, but I have
297 just brought this thing to your attention, perhaps in a different way, and it is a matter I know something about. I have lived on that river. I have been around New York for the last

forty or fifty years, and I think I know the situation pretty nearly as good as any one else. I haven't any photographs, nor anything in bottles!!! I am only giving you plain facts.

Mr. Lebkuecher: I understand that Mr. Hering feels that perhaps some of the remarks in regard to disposal have not gone into the records just right, and have perhaps been misrepresented by the opponents, and he would like you to give him an opportunity to make that clear.

Mr. Hering: Mr. Chairman, I understand, from members of the Commission, that some of the opinions I have stated were evidently misunderstood, and I would like very emphatically to have you understand just what I do think in this matter.

I am, without the slightest question, and with no hesitation, in favor of this method of disposing of the sewage of the Passaic Valley which has been recommended by the Commission; as being by far the best solution of this problem.

I have stated that, so far as the expense was concerned, I believe, from present indications, that it would be more expensive to dispose of this sewage in the next-best way,—but it seems to have been misunderstood in this way: that I said the first cost of installation would be less than with this system; but the cost of operation is so
298 large that when you take the entire cost of the problem,—the interest on the investment, the depreciation, and all of the fixed charges, and add to that the very high cost of maintenance and operation, that it would be more expensive, decidedly more expensive than this system here. I do not think that it is cheaper, irrespective of the fact that we have got a good deal to learn yet about the details.

Dr. Soper: Mr. Hering, didn't you say that that question of expense should not be a controlling incident?

Mr. Hering: I did say that.

Dr. Soper: And that you are not considering expense in this matter?

Mr. Hering: I did say that, and I wanted to advert to that now. Our experience in this matter is confined to Europe and the United States, and this whole question of sewage purification has been one that has changed its aspect every few years; and we have not reached yet a finality.

I do not believe that over the whole situation of Newark you would find an available spot to-day for putting works of this kind; and I do not believe that is a very permanent institution. I am strongly of the belief that the people would object to it and that you could not put up works of the kind there; and I believe that they would have good reason to object, because that whole territory would be depreciated in value. I count that very highly.

Then, another thing, which is still more important in my
299 estimation. When you have a work of sewage purification, it means constant attendance—constant study of how to purify this sewage at this moment in the best way; it means an intelligent management; there would have to be a force,—a large organization to conduct a work of this kind; that brings in a city department,

almost, into existence, or some part of a department, to run this thing.

Now, I have always felt that cities should be recommended that which is most simple—taking that point of view, that is, decidedly, the simplest solution for a large public work; it does not require any large force for attendance, (and you do not know whether they are always going to do everything just as it should be done) whether you are not going to get an odor, which is particularly objectionable, or that something won't go wrong. We find that even in well-regulated Europe, and, therefore, that has always been a very weighty consideration with me, for if I could dispose of the sewage in a simple way—particularly by dilution—I would always do it even if it was more expensive. If it was more expensive even, I should recommend this system than to have a work of purification, provided it cost no more, than would accrue in this case, and I only see disadvantage. I do not see any advantage in the ultimate result over this, and I see the disadvantages of the large force of operation as well as the disadvantage to the people living around it, even though they lived half a mile away from it.

Therefore, I am absolutely of the opinion that this is decidedly the best system for the territory to adopt, and I should not like to be misunderstood in that matter.

The Chairman: Is there anything else?

Mr. Hering: Now, I should just like to reply a moment to Dr. Soper, with reference to those jars of sewage—I refer to the settled sewage where all the suspended matter is deposited first, and that is that Dr. Fowler speaks of; this is not settled sewage; this is raw sewage.

Dr. Soper: I beg your pardon, this is settled sewage.

Mr. Hering: Well, then, you will have to settle that with Dr. Fowler.

Dr. Soper: I know him very well: I should be pleased to.

Mr. Hering: Another point is, I would like to mention, and that is about the flies. It was brought up twice. Now, gentlemen, the last thing I heard of in Europe this Summer, and this was in England, they were claiming how fine they were getting along,—that there was an odor, but faint, "But the flies!!" There has never been such an exhibition of flies in England or anywhere, than since these disposal systems have been introduced. They fill the contact beds; they breed right under the stones. You pick up a stone, perhaps, and under the edge, under a little bit,—all flies. We know that there are flies in connection with these plants; there may be a way of over-coming that feature; it has not been thoroughly demonstrated as yet; there are flies, floods of them in every plant and complained of very generally. Therefore, the fly question could not be used as an argument in favor of this system of sewage purification. I have not the slighest doubt there will be found some means to reduce that evil, so I do not place any weight on it, but it is an actual fact that a splendid breeding place for flies is right under the stone.

Then, too, one thing more: that is what Dr. Soper said about the

tidal stream coming up and getting the sewage and going back and getting a double dose. Now, that is perfectly correct,—but that is provided for in making a very liberal estimate of the dilution, and I would like to say this: that is no worse than storing the sewage,—holding it back until the out-going tide and then letting it go out in the out-going tide, because, then, you get a double mass of sewage on the out-going tide. It has been found better not to store up the sewage. There are exceptions to that case, but it is better to let it be dispersed and go up and down with the water, as found finally in Boston.

Mr. Schondelmeier: My name is Schondelmeier: Physician. I represent the Broadway Buyers trade and the Right Buyers Trade, of Brooklyn.

This matter of sewage has been under consideration for quite a time in these boroughts. It is a subject we all know is growing in interest, and is forced upon us.

I will not take up your time by repeating what has been said yesterday and to-day; that it is objectionable,—that it would
302 be objectionable if this trunk sewer were constructed and the sewage emptied into the Bay. I will just mention a few cases that are proof in evidence in this day that sewage plants can be constructed and operated satisfactorily. I will refer you to the sewage plant of Elmhurst, which is just above the Flushing Bay a short distance; it does its work so perfectly that as the water leaves the plant it is as clear as the water on the table which we use for drink.

We have another illustration in the sewage plant of Saratoga, where, as the water flows out into a small stream of water,—first into a large stream, located below the plant, algae develops there and other plants grow right in the water,—water coming out of the disposal plant after having been filtrated—so that it is possible to putify,—to withdraw all adulterous material from sewage. It is merely a matter of expence and wanting to do it. Saratoga has laid the problem by, as I have been told, by paying about two hundred thousand dollars for the plant, and is now running it constantly at an expense of two thousand dollars a year.

The plant at Elmhurst is minus the flies. I have proven it to my own satisfaction by having investigated it. There are practically no flies there. There is very little odor there. If those things are possible, and right near by, where it would be as reasonable to offer as an excuse that "We have not the land" and "We have not the room to institute the plant"—for they certainly have. The room is there in Jersey, as they intend to carry the sewage over twenty miles above the Bay here, right near our river-front, we
303 are disposing of it in a proper, sanitary, method.

Therefore, we do feel, and in offering this protest we offer it emphatically and earnestly, we do feel that the efforts that are being made by the City of New York and by organizations interested in the disposal of sewage in a proper way,—we do feel that others should encourage us in this work, and not ask us to permit them to do what we are endeavoring to overcome ourselves.

Mr. Lebkuecher: May I ask the gentleman what efforts the City

of Brooklyn, or what efforts the City of New York has made,—what has been done towards a sewage disposal plant in the City of Brooklyn?

Col. Knight: I fear you misunderstood him; he referred to the efforts made at Elmhurst.

Mr. Lehkuecher: I did misunderstand him.

Mr. Child: Mr. Chairman, and Gentlemen: In the few remarks I desire to make, I propose to discuss entirely the questions of obstruction to navigation. I have been living in an atmosphere of sewage for the last seven years, and the mere mention of it gives me qualms of the stomach; and I have no desire to discuss that.

As I understand it, the province of this Board, the peculiar jurisdiction of the Board is to see to it that navigation is not interfered with, either by improper construction or in any other way.

I also understand that in considering the question of the wants of navigation, that this Board will take a broad, comprehen-
304 sive view,—not confine itself to the limited section in the immediate neighborhood of Robbins Reef Light, but will look over the whole field.

It is known to you, gentlemen, that the Newark Bay is a very considerable body of water. It is known to you that the Passaic river is a navigable river for many miles up from the Bay and that the commerce of the Passaic river is very great. It is also known to you that you have had probably as much trouble in keeping matters in a proper condition in the Newark Bay and in the Passaic river as in any other territory under your jurisdiction.

Now, you cannot but say that this improvement—and we call it an improvement, and advisedly so—that this improvement will be in the interests of navigation so far as the Newark Bay is concerned, and the Passaic River. We will take out and we will keep out of that river the very things which make your task in keeping navigation open throughout that territory so difficult. That is one thing.

Now, in the next place, it is alleged, and that is all, it is alleged that some obstruction to navigation may result at the outfall of this sewage. It has not been shown that, in the Metropolitan District of Boston, any such obstruction has resulted. No complaint has been made by the Harbor Line Board having charge, unless you gentlemen may have, having charge of that territory. No one has shown to you that any result, so far as navigation is concerned, no injuries, have existed in connection with work of this character; so that you have, what? On the one side, a certain, positive
305 benefit to navigation over there in the Passaic Valley and in Newark Bay; certain, sure, unquestionable. On the other side, you have mere speculation of something which may possibly occur. Nothing has occurred in the whole history of trunk sewers,—in England, all over this country: No one has shown that it ever had occurred but it may occur.

Now, gentlemen, right in that connection, criticism has been made because these plans are said to be insufficient in detail with reference to the settling basins, the screens, and the outfall pipes.

Now, is there any uncertainty? That which can be made certain, is certain. It is certain!

This application which is pending before you is almost an exact reproduction of the application presented by the Metropolitan District (of Boston) to the Department for permission to locate each of their sewers.

Mr. Brown, who is in charge of that great Boston work, has been in our employ for years. He has been one of our consulting engineers; and, at my request, Mr. Brown sent us a copy of the last application that was made for a trunk sewer in Boston; it was on the exact lines with this, using the identical language.

Now, what do we do? What do we ask? And, before coming to that—I may be ignorant, and, if I am, I am willing to be instructed,—but I do not understand that, when the Department at Washington, acting on the recommendation of this honorable Board, grants its permission, that its jurisdiction is gone.
306 I do not understand that. It is to be only a permission: It is not a grant. It is always within the control of the Government.

Now, what are we asking? We are not asking, as has been asked thousands of times, and, I suppose, a great many times, of you, gentlemen, a right to obstruct navigation. We do not propose to take from the navigable waters any space at all. We are not proposing to build out bulkheads, extending the lines of bulkhead and pierheads: But, what are we asking? We are asking the privilege of constructing a sewer, which we represent to you will not result in any obstruction to navigation. If it does obstruct navigation, then we will stand shorn and naked of all rights coming to us by virtue of this consent, because no plea of ignorance of right principles of construction could possibly avail.

That is what I understand to be the true position, and no other position would be safe. I take it that, if the Commission should be given this consent, and we should construct a sewer and it should prove an obstruction to navigation, in the harbor of New York, in these waters, why the power is in the Department to do one of two things: Either to compel us to stop using the sewer, stop creating the obstruction, to change our plans, and to remove the obstruction.

Now, what risk does anybody run? We propose to put Twelve million five hundred thousand dollars into this project as an assurance to you gentlemen, representing the Government,
307 that we are acting in good faith; that we have faith in our representations to you, as made to you, and with the full knowledge that if those representations are false, we take nothing.

Now, what do we do? In this application, we provide here, and in the plans, and in the report which is submitted, which is made by our Commission, we are bound by every representation I have made, as well as every matter which is alleged here in this petition.

Now, what do we say? "All work in or below navigable waters, both permanent and temporary to be subject * * *"—to what?—

"to the approval and supervision of the United States authority having jurisdiction over the said waters."

Now, suppose we should—assume that our representations are false,—assuming we should construct these works without screens, without a settling basin, and that we should discharge our sewage raw, and containing heavy matter, and that it should result in an obstruction to navigation: Why, there is the authority,—we have got to get out!

There are many things of this sort that are of no use, that cannot be determined definitely, until the thing is done. But, when a man comes before you, and who claims to possess the requisite knowledge,—the man upon whom the loss, if any, must fall by reason of his failure, if it proves a failure, and he is willing to put up as an evidence of good faith an investment of over twelve million dollars, to give this Board, or the proper authority a bond which will compel us to remove each and every thing which this Board will determine to be a nuisance,—How does that
308 become a question of such great moment? The size of the settling basins! The size of the screens!

But, we go farther than that; and we want you, gentlemen, to tell us, after we have constructed the settling basin, after it is all done, and after our money is in it, if it is too small, and, if it is too small, we will make it larger,—and we will keep on increasing the size until you are satisfied.

As compared to a twelve million, two hundred and fifty thousand dollar expenditure, why, that is a bagatelle! It amounts to nothing! A piece of masonry, the size of this room, compared with the expenditure of twelve million, two hundred and fifty thousand dollars! So that that is simple enough.

It is the same thing with the screens. Why, with this bond, and with this conditional assent (because it is nothing else) it is more to our interest, having all this money at stake, to see that proper screening is effected than it can possibly be to any community, let alone any individual. Because, assuming—assuming these gentlemen who are so filled with fear and apprehension, that it may be that their fears may be realized within a reasonable time, —why, how simple it is to remove it!

Now we come, for instance, to distribution,—to the arrangements for distribution at the outfall of the plant. I do not know anything about it (and as I have heard these engineers
309 testifying here I was almost glad I did not know anything about it), I do not know whether one pipe, or five hundred pipes may or will be necessary; but, gentlemen, if five thousand pipes are necessary, we are prepared to put them there.

Now, that is all. Now, what more can we do? We say here now,—I say that all we say here, all I say, this binds us, and, as a member of this Commission I acknowledge the obligation imposed upon me when this application was presented to you gentlemen.

Before the sewage enters the pumping station it passes through a grit chamber to remove all gravel, sand and other heavy matter,

and through a screen chamber, where all floating matter will be removed. Now that is the proposition. Now, if we do not do that, then, when the time comes, you withhold your sanction and we will rest content.

It seems to me that the question is of no possible importance. It cannot be told now, as these engineers say. Well, they know more about it than we do (of course, I ought not to say that, because you gentlemen are skilled and learned in these engineering matters,—but I meant myself), but, whether they do or not, I do not know; but they tell us that they have got to wait in order to determine this. Now we will wait, but we are waiting all the time, —all the time! The grip of this Board,—the grip you gentlemen have on us is not relaxed at any time. Your successors, if there should be such, five years, ten years, from now,—indefinitely, now and then, will have exactly that authority.

310 So that I do think, gentlemen, with all deference to the various discussions that have been made, that these two matters are provided for, and that they are provided for in the best and the safest way.

What greater assurance could the Metropolitan District—and these plans are identical, as I have said—give to your Board than that it should be something which you, gentlemen, selected on account of your peculiar ability, with your knowledge, acquired after years of experience, and with your special education, should say was safe; that it was sufficient? Could any jury be selected to decide a question of this nature, more competent, or better qualified to determine such a matter?

But we will give the bond as an additional assurance; and we known that the Government will not refuse a bond——

The Chairman: Well, we don't know as to that, Commissioner,—probably you do——

Mr. Child: Well, that is my point-of-view, being unfortunately a member of the legal profession,—I have had a great deal to do with the legal matters connected with this case, which I do not propose to discuss at all. There is a tribunal before which it must be discussed before long, and Mr. Dean said that he trusted that you gentlemen would defer your decision of this matter until adjudication had been had by the Supreme Court of the United States on the pending litigation between New York and New Jersey.

The questions involved in the litigation in the United States Supreme Court are entirely foreign to any question pre-
311 sented to you, gentlemen. The question which you are called on to determine, as I understand it, is whether this proposed work will be an obstruction to navigation. Whether it is in the State of New York or in the State of New Jersey is of no possible materiality. If it is an obstruction to navigation, you gentlemen would refuse your consent if the application was made by New York or by New Jersey or if made by both, provided you believed that that would be the result.

That question is not involved in the litigation in the United States Supreme Court at all: That is purely a question of sovereign

right. To withhold this until after that decision would be, I think, a manifest injustice to my Commission. Because, there is a great deal of preliminary work which must be done in any event with reference to the construction of this sewer. Because drawings are to be made, in greater detail, of all things, and contracts prepared, ready to be put out in proper shape, and all matters of that kind, which we assume will take us from eight to ten months, and will involve the expenditure of a large amount of money.

The condition, as you heard it described here, is terrible, and ought to be abated with reasonable celerity. Now, to hold us back until the Supreme Court of the United States, acting with reference to the litigation of other questions, should render their decision would be, gentlemen, I submit to you, gentlemen, tantamount to a denial of justice. If we are entitled to it, then we ought to have it. If we are not entitled to it, then this Board ought to
312 declare that. And then, of course, some other procedure will have to be resorted to for temporary relief,—or we must bear the ills we are now subject to.

And as in this litigation the animus of the suit between New York and New Jersey being solely with reference to the suppression of this sewer,—if you should (I do not anticipate it, and do not see from my standpoint, how you can do it), but if you, in your wisdom, should determine that we are not entitled to the use of that which we are here asking for, that decision on your part would in no way affect this case,—it could not possibly have any influence upon the pending litigation in the United States Supreme Court,—that is, so far as this Passaic Valley Sewerage Commission is concerned. I presume that, the object having been obtained in another direction, it would lead to an abandonment by the State of New York. So that there is every reason to conceive of why the decision, and a reasonably quick decision, should be reached now.

It may be said now that all matters of etiquette and propriety must be decided by each individual for himself; and, of course, this Board is able to decide any question of that character. Now it may be that at first thought it will appear that it would be discourteous to the United States Supreme Court to anticipate their action. Now, as against that, I have this to say: That we were first in the field. We made our application before the suit was brought, and, on the other hand, if we had not made our
313 application to your honorable Board, the suit would not have been brought; when we made the application, the suit was brought.

And then, inasmuch as this question is not before the United States Supreme Court, and cannot affect—either directly or indirectly—so far as the legal considerations are concerned—any decision which they may reach, I do not see how it is a violation of any of the rules of strictest courtesy.

Of course, if you consider the character of that tribunal, and of the honorable body of men sitting to-day in the United States Supreme Court, it would be folly for any man to believe that they would be influenced in their determination of a question of right,

by a conclusion reached by another tribunal on another and independent point.

Now, with these remarks, gentlemen, I am through; thanking you for the courtesy of your attention. I trust that this Board will see its way clear to grant to the State of New Jersey,—the important part of the State of New Jersey, the relief so imperatively demanded.

Mr. Lebkuecher: May I be allowed to ask Mr. Riker to make a few remarks?

The Chairman: On this phase of the question?

Mr. Lebkuecher: Yes, sir.

The Chairman: I do not think it necessary, that is, if I understand it to be in duplication or reiteration of what has been said——

Mr. Lebkuecher: Merely for the purpose of strengthen-
314 ing it——

The Chairman: I do not think it is necessary. Do you undertsand that if there is anything further to be brought out, the Board is prepared to continue this session, tomorrow, if necessary.

Mr. Lebkuecher: I think we are about through, Mr. Chairman; we have nothing more to present.

The Chairman: Gentlemen, is there any one here who desires to say anything more on this question? The Board desires to give everybody an opportunity——

Mr. Sandford: One remark I would like to make is that I do not know whether the gentlemen are aware that the United States Government, at the present time, are spending a great deal of money on the Passaic river, to make it navigable for larger vessels——

The Chairman: That is entirely within the knowledge of the Board.

Mr. Sandford: I wanted to say, in connection with that, that unless we can get factories and warehouses and so forth, along that shore, where people can work in, why, the deepening of that river will be lost to the community.

Mr. Lebkuecher: Have you all of the data you require, from our Commission?

The Chairman: Everything that has been handed to the Board——

Mr. Child: I do not know as to whether I was understood this morning, when I handed you the extracts from the United
315 States Coast Survey Reports,—I spent considerable time over the Coast Survey reports, and I think you will find them very interesting. They cover all the principles of New York harbor, as to currents, and so forth. I am not going to refer to all of the different data, but it is a comprehensive index to the Bay.

The Chairman: The Board will be prepared to receive any communications bearing on this subject at any time up to and including Monday——

Col. Knight: Why not make it Monday a week, and give them ample time——

The Chairman: Up to and including Monday, December 21st.

The hearing is adjourned.

Complainants' Exhibit No. 2. James D. Maher, Commissioner.

State of New York:

W. J. Sullivan.

Report of the New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, March 31, 1905.

Commissioners: Daniel Lewis, Chairman; Olin H. Landreth, Myron S. Falk, George A. Soper, Louis L. Tribus, Secretary.

Transmitted to the Legislature May 1, 1905.

Compliments of the New York Bay Pollution Commission. Louis L. Tribus, C. E., Secretary, 84 Warren St., New York City, Oct. 1905.

(Here follows map marked page 1, Exhibit No. 2.)

3 STATE OF NEW YORK:

W. J. Sullivan.

Report of the New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, March 31, 1905.

Commissioners: Daniel Lewis, Chairman; Olin H. Landreth, Myron S. Falk, George A. Soper, Louis L. Tribus, Secretary.

Transmitted to the Legislature May 1, 1905.

4 STATE OF NEW YORK:

No. 39.

In Senate, May 1, 1905.

Report of the New York Bay Pollution Commission to Frank Wayland Higgins, Governor of the State.

Commissioners: Daniel Lewis, Chairman; Olin H. Landreth, George A. Soper, Myron S. Falk, Louis L. Tribus, Secretary.

Hon. Frank Wayland Higgins, Governor State of New York, Albany, N. Y.

SIR: The New York Bay Pollution Commission respectfully reports to you herein the main facts concerning its researches and its recommendations.

Report of New York Bay Pollution Commission..... 5

Appendix 1.

Report on Tidal and River Flow, by Myron S. Falk..... 33

Appendix 2.

Report on Present Sewage Pollution of New York Harbor, by Louis L. Tribus..... 42

Appendix 3.

Report on Sanitary and Bacteriological Conditions, Fisheries and Industries affected by Pollution in New York Harbor, by George A. Soper..... 47

Appendix 4.

Report on Legislative and Documentary History of the Passaic Valley Project and Ocean Disposal of Wastes, by Olin H. Landreth 89

Appendix 5.

Report on Needs of the Metropolitan District and Desirability of Joint State Action, by Daniel Lewis..... 106

Appendix 6.

Legal opinion on Questions submitted, by Attorney-General John Cunneen 109

Appendix 7.

Law of 1903—New York State—authorizing appointment of New York Bay Pollution Commission..... 119

Appendix 8.

Proposed Act for 1905—for appointment of a Metropolitan Sewerage Commission and other recommendations of the New York Bay Pollution Commission..... 121

Appendix 9.

Abstract of Minutes—Meetings of New York Bay Pollution Commission 125

Appendix 10.

Financial Statement of New York Bay Pollution Commission. 128

Appendix 11.

Names of those rendering special assistance to the New York Bay Pollution Commission 130
Index 133

6 Causes Leading to Appointment of Commission.

The State Department of Health, having for years noted with anxiety the increasing pollution of New York harbor, due to the discharge into its waters, of sewage and factory wastes of all kinds from the different boroughs of the city of New York, the city of Yonkers, and the cities and towns in the State of New Jersey, situated along the banks of the Hudson river, New York bay and their tributaries and estuaries, and this pollution having culminated in the proposed construction of an immense sewer to discharge the waste from a large territory in New Jersey, not contiguous to the waters of New York bay, brought the matter to the attention of Governor Odell, who thereupon invited legislative action.

The Passaic river (lying wholly within the State of New Jersey) but flowing into one of the estuaries of the harbor, became years ago so foul with sewage coming from the cities along its banks, that a serious nuisance was created, menacing the health and comfort of the adjoining and lower communities. It discharges into the tidal waters of Newark bay, which opens in turn into Staten Island sound and Kill von Kull; thence into New York bay, respectively the lower and upper portions, though as yet these latter waters have not evidenced a condition where annoyance is strongly apparent;—Newark bay having acted as a diffusing, settling and partial purification basin;—but with the possibility that a nuisance will be created.

The State of New Jersey had authorized the preparation of plans and the issuance of bonds for constructing a large trunk sewer which, when completed, would free the Passaic river and Newark bay in large measure, from the sewage of Newark, Paterson, Passaic and many smaller communities within the drainage area.

7 The plan proposed to conduct all this sewage across Newark bay; thence across the city of Bayonne, and empty it into New York bay within the State of New Jersey, but near the interstate line, on the margin of the deep water channel, at a point about one mile north of Robbins Reef light.

There was thus contemplated the discharge of the house wastes and factory refuse from a population of between one and two millions of people, directly into New York harbor at one, two, or three points, located near together.

Opposition to the project which has developed in the State of New Jersey need not be considered in this report, though upon various grounds it has been considerable.

Legislative Action, New York State.

The subject was brought to the attention of the New York Legislature of 1903, which forthwith enacted Chapter 539, becoming a law May 11, 1903, entitled "An act to authorize the appointment by the Governor, of a commission to investigate certain threatened pollution of the waters of New York bay and making an appropriation for the expenses of such commission."

The salient points of said act being (abstracts as follows):

Section 1. Authorizing the Governor to appoint a commission of five members to serve without compensation.

Section 2. Directing said commission to confer with the authorities of the State of New Jersey; to take testimony of witnesses and make such investigations as should seem desirable to determine the character of the threatened pollution, if any, and the means necessary to effectively prevent the same.

Section 3. Giving power to said commission to administer oaths, subpœna witnesses, and such other powers as Article 3 of the Legislative laws gives to Legislative committees; and requiring the commission to report to the Governor the result of such investigations and its recommendations as to legislation, etc.

Section 4. Appropriating moneys for the necessary traveling and other expenses of the commission.

Section 5. Making the act effective at once.

Work of the Commission.

On June 2, 1903, the appointments of the commissioners were forwarded, and on the 30th of that month the first meeting was held, at which an outline of procedure was prepared and assignments made to the different members, of subjects for their special investigation.

As appendices to this report will be found in full these special reports, which have been fully discussed at the meetings and from which, with testimony taken at public hearings and joint conferences with the Passaic Valley District Sewage Commission have been derived the conclusions.

The Special Subjects are as Follows:

Appendix 1. Tidal action and river flow in harbor of New York, by Commissioner Myron S. Falk.

Appendix 2. Present sources and estimated quantities of sewage coming from different communities in and about New York harbor, by Commissioner Louis L. Tribus.

Appendix 3. Sanitary and bacteriological analyses of New York harbor waters and fisheries; and industries affected by pollution, by Commissioner George A. Soper.

Appendix 4. (A) The history, laws, reports and plans of the New Jersey project, and (B) ocean disposal as a possible solution for all the metropolitan sewage nuisance, by Commissioner Olin H. Landreth.

Appendix 5. Needs of the metropolitan district as a whole and desirability of joint State action, by Commissioner Daniel Lewis.

Appendix 6. Legal rights and powers of New York State to prevent pollution, by Attorney-General John Cunneen.

In addition to these special reports there will be found herein:

Appendix 7. Law authorizing appointment of commission.

Appendix 8. Proposed Legislative bill.

3061

Appendix 9. List of meetings held by the commission and special features considered thereat.

Appendix 10. Statement of disbursements.

Appendix 11. List of those who have rendered special assistance to the commission.

Map, showing: Tidal action New York harbor (see Appendix 1).

Sewer outlets at margin of harbor waters (see Appendix 2).

Shellfish beds and position of points from where water and shellfish samples were taken for analyses (see Appendix 3).

Passaic valley sewerage district and proposed location of outlet (see report of New Jersey Passaic Valley District Sewerage Commission).

There also will be filed at Albany full minutes of the different meetings, both in executive session and in joint session with the New Jersey authorities, and a copy of the report of the Passaic Valley District Sewerage Commission, and testimony of experts retained thereby.

10 In connection with the joint investigations, a number of personal studies have been made by different members of the commission, of the most recent systems of sewage treatment and disposal, so that possibilities of other means of disposal than at present planned by the State of New Jersey could be intelligently considered, though it has not been thought proper to suggest any special course for New Jersey to follow.

Tidal Conditions, New York Harbor.

Assuming that the Passaic valley trunk sewer has been constructed with one, two or three outlets north of Robbins Reef light, the action of the tidal currents would very largely determine the question whether the sewage discharge would be likely to become an offense to the senses or not, even considering that the sewage would ultimately become diffused, and that the water in the harbor is sufficient to safely and rapidly dilute so large a concentrated flow. If the sewage should be discharged at a uniform rate throughout the twenty-four hours, as has been contemplated by the Passaic Valley District Sewerage Commission, it is unquestionable that some of the sewage would be carried by the inflowing tide northwards into the Hudson and East rivers, and on the outgoing tide southward to the shores of Staten Island. If the sewage should be retained so as to have the outflow only on the stronger run of the ebb tide, the percentage to go northward would be greatly reduced, helping the upper harbor, but the percentage reaching the shores of Staten Island would be greatly increased; and though the total quantity of sewage in twenty-four hours would be no greater, it would be discharged in practically eight instead of twenty-four hours; so that the quantity at any given time during the outflow would be three times as great as on a continual flow basis.

11 A matter of much importance in considering the dispersion of sewage is the question of the under-run of salt water beneath the fresher waters from the Hudson. The difference in specific gravity between the two waters may be as high as 2½ per

cent. There is thus a tendency for the salt water to force itself up the river for a considerable distance and to remain stagnant while the fresher waters follow their way down to the sea. This tendency is marked at low water stages in the river. It does not seem improbable, therefore, that some of the sewage discharged at from 30 to 40 feet beneath the surface would even during a strong ebb tide for the upper layers of water encounter strong up-stream currents and be, therefore, carried well up the bay and even some distance up the Hudson river. The full effect of this under-current is not known, but its existence has been noted and it might almost totally vitiate the efforts to dispose of sewage from the proposed Passaic valley trunk sewer by means of tidal carriage and diffusion. It might be that for some years the collecting of this sewage in the potholes or basins of the bay and the river would not create a nuisance noticeable on the surface or in the great body of water, but it is certainly desirable to guard against such a possibility.

In any case, the subject is one more largely of tidal phenomena than straight diffusion, except as to the great probability of a local nuisance being created near the outlet pipes;—one which, if created, would be apparent from boats passing along the main channel to and from Kill von Kull; the ferry lines between Manhattan and Richmond, the many vessels anchoring on the west side of the main ship channel, particularly in Summer, and to many of the steamers and excursion boats passing in and out of the bay.

12 The expert advisers of the Passaic Valley District Sewerage Commission unite in the opinion that on a twenty-four-hour outflow the diffusion of sewage would be so great immediately on its entering the waters of the bay as to create no nuisance. They are less certain as to the effect of having the discharge during the shorter number of hours so as to make more use of the ebb tide. In the latter case they think there might be trouble, in the former they estimate that there will be none; scarcely a safe ground to stand on in a vital question.

It has been practically impossible to secure exact figures as to the tidal flow phenomena, though United States government engineers some years ago conducted a series of observations and tests. From them and such other data as have been secured, it seems probable that a quantity of water not far from twelve to thirteen billion cubic feet enters the upper bay at each of the tides per day. Of this amount, the approximate figures may perhaps be:

4,250 million cubic feet into the East river;

6,750 million cubic feet into the Hudson river;

1,750 million cubic feet into the Kill von Kull.

The areaas of the tidal basins receiving this flow are approximately as follows:

Kill von Kull, Newark bay, and the Passaic and Hackensack rivers about 14.2 square miles.

The Upper bay about 21.6 square miles.

The East river about 4.5 square miles.

While the Hudson river has a tidal area equal probably to all the others combined.

The ebb tide coming down the Hudson meets the ebb tide coming eastward out of the Kill von Kull; they both reach in and
13 strike Staten Island between Stapleton and Clifton, at a point distant about three to four miles from Robbins Reef light. It then makes along the shore and traveling along the beach makes Forth Wadsworth. At this same time there is also an ebb coming from Arthur Kill (or Staten Island sound) and Raritan river which, striking the main current, tends to throw it to the eastward again in the lower bay. In calm weather the force of the main tide through the Narrows may reach as far as Swinburne Island and Orchard Shoal. Strong winds at all times tend to deflect the currents somewhat.

The first effect of the flood through the Narrows is to strike the shore of Staten Island a little to the north of the point where the first effect of the ebb is felt. The second effect of the flood is reaching into the flats of the Upper bay to the west of Robbins' Reef. The third is to flow into the Kill von Kull, and the fourth and final effect to flow into the Hudson and East rivers. After the first of the flood the tide also travels up on the Brooklyn side. It is probate that in calm weather the maximum effect of the flood tide is felt on the northwest side of the Upper bay.

The tidal ebb is detected by discoloration of the water five or six miles from the outer face of the bar; sometimes even outside of Sandy Hook lightship, but there seems to be little concentration of effect, at that distance from the Narrows.

The published Government reports give the maximum ebb velocity of the current in the Narrows at 1.5 knots and the maximum flood 1.2 knots per hour. In the Hudson river off Thirty-ninth street these figures are respectively 2.7 and 2.0 knots, and in the East river off Twenty-third street, 2.0 and 1.8 knots. Estimating a constant velocity of discharge during the various tidal periods of the day, the average ebb velocity at the Narrows would
14 reduce to 1.61 miles per hour, the average flood velocity to 1.48 miles per hour.

It is probable that some of the sewage which reaches the radius of action of the active tidal ebb flow, will ultimately be carried out of the harbor to the ocean, though taking several days in the process, but it is not so evident that all of the sewage or even that the major part of it, will reach such radius of action, so would remain in the harbor for gradual putrefaction and breaking up.

If the diffusion and rapid oxidation should not be so great as is anticipated by the Passaic commissioners, it is not difficult to imagine the creation of a condition of affairs decidedly unpleasant to the senses, if not necessarily detrimental to health, particularly along the shores of Staten Island and in the path of many vessels.

Present Pollution of New York Harbor.

The Hudson river receives sewage from many of the larger cities and towns of New York State, which it discharges into the harbor of New York, but being affected by tidal action as far north as Albany, and the combined fresh water and tidal volumes so greatly

exceeding the total quality of sewage, no general nuisance has as yet been created, nor does such seem likely to arise in the near future. Some of the streams tributary to the Hudson do present, however, very serious conditions. The cities along the Hudson, south of Albany, are daily pouring their millions of gallons of filth into the river, but not creating as yet any noticeable nuisance, except near the outlets. To what extent this sewage undergoes organic change by the time it reaches New York harbor is a question difficult of determination. If a complete change does not take place,
15 so thorough a diffusion does occur as to prevent any serious nuisance being apparent. The condition is not so certain, however, as to the outflow from the several hundred sewers entering New York harbor at both sides of the Hudson river from the Yonkers line southward; in the various kills and bays, and in Long Island sound within the radius of action of the harbor's tidal flow. It should be said in fairness, that at the present day the waters of New York harbor in general are not so polluted as to be offensive to the senses, though such is the case in some of its estuaries and smaller bays.

Without elaborate study, no one can estimate with precision, however, the exact degree of pollution permissible, before the conditions would reach a serious stage. The following table gives estimates of the present normal daily sewage flow from existing sewers; that proposed (based on present conditions) from the Passaic Valley trunk sewer and that from another large system lately constructed, which will accommodate South Orange and other communities in that portion of New Jersey, as well as a considerable portion of the city of Elizabeth.

From locality.	Estimated present population.	Estimated daily dry weather sewage flow in gallons.
Communities on shores of New York Harbor	4,470,000	447,000,000
Part of Elizabeth and South Orange District	80,000	8,000,000
Part of Passaic Valley District	500,000	50,000,000
Totals	5,050,000	505,000,000

On the map accompanying this report has been indicated the outlet points of all sewers of which information could be secured, the table in Appendix 2 showing their respective discharges. Most of these accommodate storm flow as well as sanitary sewage.
16 Ordinarily, of course, they only handle house and manufacturing wastes and some street washings; but immediately following rain storms, a great deal of additional filth from the streets reaches the harbor, in quantity probably averaging some 350 million gallons per day. The normal pollution however may be considered, to be chiefly the outflow of house and manufacturing wastes, rejected by about five million inhabitants of New York and neighboring communities.

The saving feature of the present discharge is that it debouches at so many different points that very thorough dilution occurs and any great localized nuisance is avoided,—a condition which could not

be predicted if the whole flow should be gathered into five or six outlets, each having the capacity of the proposed Passaic Valley trunk sewer.

It must be borne in mind in considering all such matters as those made the subject of this report, that the best or even average conditions are not those which govern the case, but that the worst possible conditions which may arise are those which should determine conclusions; consequently, it is not the immediate plan of the Passaic Valley District Sewerage Commission which needs to be thought of as possibly dangerous, but the ultimate plan contemplated and not only with regard to the New Jersey project or projects, but concerning all sewerage works having present or proposed future entrance into New York Harbor and its bays or branches. In questions of this character, years must necessarily intervene between the initiation and the consummation of projects, so that future nuisance must be anticipated and relief measures considered many years before either the nuisance has been created or the relief can be given.

17 Sanitary and Bacteriological Condition of New York Harbor and Its Fisheries and the Industries Affected by Pollution of the Waters.

From the studies of the commission it is evident that the present pollution of New York Bay, although not great, is distinctly measureable by chemical and bacteriological analyses, and careful studies of the relative proportions of sea and fresh waters in the bay and rivers about New York show that the sewage of New York city is not promptly flushed out to sea, except perchance during time of heavy freshets from the Hudson. The water of the incoming tide is not ordinarily much purer than the water of the outgoing tide, as noted in the Upper bay, yet it is probable that most of the sewage now entering the harbor is disposed of in the harbor itself by the lower orders of animal and plant life found abundantly in the waters, the chief effect of the tide seeming to be the production of currents whereby the sewage becomes mixed and diffused. Without special and experimental studies it is impossible to estimate with clearness how large a proportion of sewage and other organic matter can be emptied into the harbor without killing these forms of life which now destroy it. Immediately follow- their destruction would unquestionably develop an intolerable nuisance. It is estimated that every 24 hours there is deposited from the sewers of New York and vicinity an equivalent of 1,047 tons of dry sludge, about one-half of which may be assumed to be organic matter.

The oyster beds of New York bay are almost exclusively found on the southeast side of Staten Island and in Gravesend bay. Most of these shellfish beds are now free from dangerous pollution,
18 though some of them are found to be nearer sewer outfalls than is wise or proper.

Analyses of oysters and clams made under the direction of the commission show that shellfish grown or immersed for some hours in polluted water, become polluted themselves. This fact is of peculiar

importance, for the custom is almost a universal one of taking oysters from their natural beds and depositing them for a few hours or days in the mouths of fresh-water streams adjoining the coast; streams which are almost invariably seriously polluted, the object being to give the oysters a so-called "drink" which results in bleaching and bloating them.

Fish caught in the harbor do not seem to have given evidence of impairment of their meat due to polluting matters, except at certain times in the past from special causes such as the outpouring of petroleum and other industrial wastes.

It is probable that about 1,000,000 bushels of market oysters and clams are taken from the waters of New York harbor annually, at an approximate valuation of about $900,000. The fishing of importance in the same waters, practically confined to the catch of shad in the very short spring season, which amounted in 1901, the heaviest year since 1888, to less than 3,500,000 pounds, valued at about $110,000. From these figures the question of interference with fisheries cannot be considered a very serious one from the industrial point of view should the whole industry disappear. Should disease, however, be disseminated from the eating of polluted shellfish before such time as the industry shall disappear from New York harbor, the consequences might be very serious.

There have been taken during the past season about fifty samples of water from the harbor, at points between the Battery and
19 Coney Island on one side, and the Battery and Raritan bay on the other. These were analyzed with the result that colon bacillus, an invariable accompaniment of sewage was generally indicated by the "presumptive test." These analyses were made in the Prospect Laboratory, Brooklyn, by one trained in water analysis. A few specimens were also sent for examination to the Bender Hygienic Laboratory at Albany. Some fifty-one specimens of oysters and clams were also taken from their natural beds and examined in a similar way for evidence of the colon bacillus. The results show that wherever the waters indicated pollution, the oysters were themselves found to share in the pollution; while in general the samples taken from the localities where the pollution of the water was not appreciable, were wholesome: the samples taken from the "drinking grounds" showed greater evidence of pollution than those from the natural beds.

Chemical examination of the waters made for this commission and by others show distinct evidence of pollution both at ebb and flood tides, particularly in the Upper bay, though the examinations do not warrant the opinion that the water is everywhere and at all times contaminated, but that traces of pollution can sometimes be found after the sewage has been thoroughly commingled with the waters of the bay and has traveled miles from its point of origin. The commission does not desire, however, to base too great importance on these analyses. Such analyses are rather indicative of lines of investigation than conclusive in themselves.

Concerning other industries likely to be affected by serious pollution of the waters, it should be noted that excursion steamers car-

ried in 1903 nearly 2,500,000 passengers to bathing beaches
20 and day summer resorts, on or near New York bay, where have been invested a number of million dollars which would be jeopardized by serious pollution of the adjoining waters. The ferries carries during 1903 something over 200,000,000 passengers of whom nearly 9,000,000 crossed the centre of the Upper bay. These passengers are entitled to have their trip kept free from an offensive condition of the harbor waters which will unquestionably develop in time, if the present rate of increase in sewage flow continues and should be added to by the full proposed discharge from the Passaic Valley trunk sewer. The nearest precedent to the construction of such a sewer as is proposed by the State of New Jersey, and the discharge of sewage at either one or several points near together is from the system of the city of Boston and metropolitan districts adjoining, where a discharge at Deer Island in Boston harbor of about 40,000,000 gallons of sewage per day causes the waters about the outlet to be discolored over an area of approximately three-quarters of a square mile. At Moon Island, in Boston harbor, a discharge of about 22,000,000 gallons of sewage in less than one hour coming from tidal detention basins discolors about one and one-quarter square miles, fully two-thirds of this area being offensive to both sight and smell. It seems possible that the sewage from the proposed outfall of the Passaic Valley trunk sewer would discolor and render more or less offensive, well towards five square miles of the most beautiful and most traveled part of New York bay, covering the water on calm days at least, with "sleek" or a thin film of grease, which might extend to Liberty, Ellis and Governors Islands and at times even as far as the Battery, Brooklyn and much of the north and easterly shores of Staten Island.

21 Legislative and Reported History of the New Jersey Project.

Chapter 7 of the Laws of 1896 of the State of New Jersey was entitled "An act for the consideration of the general system of sewage disposal for the valley of the Passaic river and prevention of the pollution thereof."

This law provided for the appointment by the Governor of three citizens of New Jersey to consider the general project. Ten thousand dollars were appropriated to defray the expenses of their investigations.

The report of the commission subsequently appointed by Governor Griggs was submitted to the Legislature Feb. 26, 1897, and included the individual reports of the engineer, chemist, bacteriologist, and secretary, with conclusions and recommendations, including the draft of "An act providing for the purification of the rivers and streams of water within this State (New Jersey) and prevent the pollution of the same."

The Legislature on March 24, 1897, passed an act, becoming chapter 35 of the Laws of 1897, to prevent the wilful pollution of the Passaic river and the tributaries thereof, above the Great Falls of the

Passaic River at Paterson; said act being evidently intended rather to protect the purity of the water supply controlled by the East Jersey Water Company than to reduce the pollution in the lower Passaic Valley.

The report of the commission of 1896 above referred to, did not result in the passage of the law desired, but did result in the passage of an act authorizing a committee of members of the Legislature to study the subject and report at the next session. Various public hearings were held, and in the spring of 1898 the committee
22 reported as a result of its labors that the whole matter ought to be again studied by a new commission, which commission was duly appointed by Governor Vorhees.

The Legislature of 1899 again took up the matter and passed a bill, forming chapter 210 of the Laws of 1899, entitled, "An act to prevent the pollution of the waters in this State (New Jersey) by the establishment of a State Sewerage Commission, authorizing the creation of sewerage districts and district sewerage boards and prescribing and regulating the duties and powers of such commission and such boards." The sum of $5,000 was appropriated for expenses. It may be noted that the functions of this State sewerage commission are general and are not confined to the Passaic Valley solely. This commission has filed several annual reports, viz., for the years 1899, 1900, 1901, and 1902. As a result of their recommendation a law was passed giving additional powers to the commission, by which it could compel the abatement of existing nuisances of certain classes, and authorizing two or more municipalities to cooperate in providing for sewer systems and sewage disposal plants.

In 1900 the Legislature amended the original law, establishing the State Commission, reenacting it as chapter 72 of the Laws of 1900, giving rather broader powers. In 1902 the Legislature passed an act (chapter 48 of the Laws of 1902) establishing a separate sewerage district for the Passaic Valley, and creating a special commission therefor. The State commission since then has been enabled to devote its energies to other localities. The same Legislature also passed an act, becoming chapter 49, providing for the creation and incorporation of sewerage and drainage districts, for each of which the Governor could appoint a commission of five residents of such sewerage district.

23 Under the two laws just referred to, the "Passaic Valley Sewerage District" was created and a commission of five members appointed. This commission organized April 22, 1902, and selected a chief engineer. It submitted its first report to the Legislature on January 23, 1903, containing the report of its chief engineer and a draft of a proposed bill which would more thoroughly provide for carrying out the improvements recommended than possible under existing laws. The studies included two alternative general plans: First, a system of intercepting sewers extending from Paterson to Newark bay, by which the sewage of the valley would be brought to and discharged into the waters of upper New York bay without preliminary purification; second, a similar system of intercepting sewers, but in place of crude disposal, to construct one

or more purification plants where the sewage would first be treated and the purified effluent discharged into the Passaic river or Newark bay. The former plan was recommended by the chief engineer, and is the plan adopted by the Passaic Valley District Sewerage Commission for execution.

It comprises a main interceptor extending from a point near the Great Falls of the Passaic, in the city of Paterson, along the right or westerly bank of the Passaic river to a point in the city of Newark, where it leaves the river and passes southeasterly through the city, across the salt meadows to a point on the shore of Newark bay, about opposite West Bergen Point, where a main pumping station is to be located. From the pumping station the sewage is to be forced through two steel force mains (six feet each in diameter) under Newark bay and up into a gravity sewer thirteen feet in diameter, leading southeasterly along the Morris and Essex canal to a point jutting out into upper New York bay near Pamrapo; from
24 whence the sewage would pass through an eight foot steel pipe leading under New York bay, to a point about three-quarters of a mile northeast of Robbins reef light and opening out in a depth of water of about forty feet below mean low tide.

The Legislature of 1903 passed an act on April 22, modifying somewhat the provisions of the law, to effect, that before any work should be undertaken or obligations incurred, the Passaic Valley Sewerage Commission should investigate whether the proposed discharge of sewage into New York bay is likely to pollute the waters of said bay to such an extent or to such a degree as to create a nuisance to persons or property within the State of New York; and that no work should be carried out until after such investigation had been made and report presented thereon, and until the Attorney-General should in writing advise that no cause of action, either for damage or injunction, would arise in favor of the State of New York or any of its inhabitants by reason of said proposed discharge of sewage.

On June 8, 1903, such special report was submitted giving the opinion of the commission that such discharge of sewage would not pollute the waters of New York bay to such an extent or to such a degree as to cause a nuisance to persons or property within the State of New York; the conclusions of the commission being largely based upon written opinions received from a number of well-known engineers. Governor Murphy having examined the special report, referred it to the State Attorney-General for legal opinion, who advised that in his opinion there would be no legal objection from the authorities of New York. The Governor thereupon authorized the sewer commission to proceed to the construction of the improvements contemplated, and the Supreme Court upon certiorari proceedings upheld the constitutionality of the act. Prior to the report
25 above mentioned the Legislature of the State of New York authorized the appointment of the New York Bay Pollution Commission, which is now filing its report, objections and recommendations.

On March 6, 1905, the Court of Errors and Appeals of the State

of New Jersey declared unconstitutional the act of 1903, under which the Passaic Valley District Sewerage Commission proposed to construct its great trunk system and empty the sewage into New York bay; ten judges being in favor of reversing the Supreme Court which had declared the act constitutional, and but one judge upholding said court. The fatal defect was held to be the method provided for levying taxes to meet the cost of construction and maintenance. Consequently, the immediate threatened danger from the special sewerage system, which caused the appointment of this commission, is delayed by this decision of the New Jersey judiciary. Undoubtedly, however, there will be renewed attempts to pass an act which will avoid the defects of the former ones, so that New York State should continue to take cognizance of this question, and the greater one of general pollution of the harbor as well.

Possible Ocean Disposal of All Sewerage Wastes.

The waters of New York harbor and vicinity are invaluable to the inhabitants of the metropolitan district in their facilitation of New York's enormous commerce, the fact being well established that water communication is far more economical and convenient than land systems. In the relation of the waters to climatic and sanitary conditions the value is also beyond computation, in tempering both heat of the summer and the cold of the winter; and in carrying off or assimilating a large portion of the waste products of civilization which inevitably reach them even when sewers
26 can be made to carry a large part of the wastes to distant points. Probably over a million persons from the district cross these waters at many points daily in going between their homes and their places of business.

While a great deal has been done in the way of caring for urban waste in the final disposal of garbage and purification of sewage, no practical steps have as yet been taken in the metropolitan district towards relieving the district entirely from the sewage being poured into the waters of the harbor by the hundreds of millions of gallons daily. The only consideration that has been given as a rule, has been to conduct the sewage by the cheapest possible route and means to tidal waters, practically regardless of the effect upon them. But two real systems of ultimate final disposal are open to the district as a whole,—one, improved sewage disposal plants for each local district or municipality, established within its own boundaries, which plants would so treat the sewage as to make the effluent innocuous and inoffensive when it reaches the waters of the harbor, the solids being removed or destroyed; the other, the carrying out of some comprehensive scheme for ocean disposal of the crude sewage from the whole metropolitan district lying in New York and New Jersey either by one or by several great trunk sewers or tunnels.

A work of such magnitude can only be suggested at this time in the barest outline, as studies and plans would need to be exceedingly exhaustive and in great detail in order to properly conserve the sanitary and financial interests of the districts affected.

In general the conclusions of the commission would seem to be that owing to the nature of the development of New York city
27 and its environs, the first plan of separate utilization plans would be practically impossible of execution. Therefore, the other plan of ultimate ocean disposal seems to offer the most promising possible solution of the whole question, and one worthy of the fullest and most thorough investigation and development.

Needs of the Whole District and Desirability of Joint State Action.

The commission, from the very inception of its investigations, has been confronted with the fact that the construction of the proposed Passaic Valley sewer is only one of many similar problems demanding legislative action for the protection of the waters of New York bay sewage contamination.

The contention of the New Jersey commission that because the bay is now more or less directly receiving raw sewage from 4,000,000 people, therefore an increase from 1,000,000 more should be permitted is untenable.

The harbor is now an immense cesspool, which like smaller receptacles of sewage, has a natural limit of capacity, beyond which lies the danger to the health and comfort of the contiguous metropolitan district. The residents of New Jersey, who thus expected to discharge their waste through the proposed sewer, are equally interested with the inhabitants of New York city in preserving the waters of the harbor from further contamination.

The establishment of a metropolitan sewerage district has been suggested, to include all sections in both New York State and New Jersey which now or in future might sewer into the bay and its tributaries. Such a district, when authorized by joint State and federal legislation, should be under the direction and control of a permanent interstate commission, with plenary power to
28 control the discharge of all sewers hereafter constructed, as well as the evolving of a comprehensive plan for ultimately rendering the present chaotic and systemless method of sewage disposal, sanitary and suitable for all future requirements.

The necessity already exists for a central authority to not only direct, but also initiate such great public works, upon which depend the beauty and healthfulness of the approximately 450 miles of shore within the metropolitan district.

Legal Status of New York's Jurisdiction Over the Harbor Waters.

Certain questions were presented to State Attorney-General Cunneen from whose replies, abstracts are herein presented (the full answers in Appendix 6).

1. What is the status of the waters of New York harbor as to control over pollution, by the Federal Government and by the two States of New York and New Jersey?

Answer. In the year 1833 an agreement was entered into between these two States, subsequently ratified by their Legislatures and

approved by Congress, which established the common boundary line and which conceded to New York the exclusive jurisdiction of, and over, all waters of the bay of New York, and of, and over, all the waters of the Hudson river lying west of Manhattan Island and southward from Spuyten Duyvil creek, to low water mark on the westerly or New Jersey side thereof, subject to rights of property and of jurisdiction over the same by the State of New Jersey, from the joint boundary line westward and northward respectively; except that vessels even tied to New Jersey docks should be subject to the quarantine or health laws and laws in relation to passengers in the State of New York as they then existed or that might thereafter be passed. The right of regulating fisheries to the westward of the joint boundary line was reserved to the State of New Jersey.

The New York Court of Appeals in one of its decisions deduced a rule which indicated that New York had the right under the agreement to enforce quarantine and sanitary laws over all the waters of New York harbor as described, though both States could retain their absolute control over land under water and docks, vessels or other floating craft attached to any wharf or pier, as far as property rights were concerned; or violation of laws other than those offences against New York quarantine or health laws.

2. Whether the Federal Government would have jurisdiction over any phase of construction and operation of a large proposed trunk sewer to empty into the waters of New York harbor?

Answer. Federal jurisdiction is concerned specially with interference with navigation; consequently if the Passaic Valley trunk sewer should be so constructed as to interfere with navigation, or should its construction and operation be likely to so interfere, the Federal Government would undoubtedly have the right to interpose objection through an action brought in the Supreme Court of the United States. Such action was unchallenged by the State of Missouri against the State of Illinois and the sanitary district of Chicago, concerning the construction and operation of the Chicago drainage canal which proposed to carry sewage from the city of Chicago through a canal and the Illinois river to the Mississippi river. The bill in the action was demurred to, but the court sustained the right of the State of Missouri to maintain its proceedings, based on the sanitary features of the case. Consequently the Federal Government, as represented by the Supreme Court of the United States, would seem to have jurisdiction, not alone on the score of interference with navigation, but to recognize an action brought by the State of New York, in said court, to compel the State of New Jersey and the Passaic Valley District Sewerage Commission to refrain from polluting the waters of New York harbor with so great a mass of sewage as that contemplated, on sanitary grounds.

3. What power, if any, has the State of New York to impose conditions upon the State of New Jersey as to constructing the proposed sewer and to operating it in future?

Answer. The State of New York could only force action or non-

action by the State of New Jersey by proceedings brought before the Supreme Court of the United States.

4. Whether the New York Bay Pollution Commission is authorized by law to suggest detailed plans for any changes in construction of the New Jersey sewer if same is to discharge into the waters of New York bay, and objection be made to the present plans as formulated by the New Jersey Commission?

Answer. There seems to be no objection to the New York Commission making suggestions and recommendations to the New Jersey Commission, though such suggestions could not be enforced.

5. Whether in the event this commission finds it desirable to recommend for future consideration the establishment of a metropolitan district covering parts of the two States of New York and New Jersey, the Legislatures of the two States have authority to establish such district and appoint a commission having adequate powers of administration?

Answer. The legislatures of the two States could undoubtedly establish in each State respectively, a certain district to
31 adjoin a similar district in the other state, and give jurisdiction thereover, to the courts of one or the other of said two States as to all matters pertaining to the sewerage of said district; but it would seem desirable that such possible concurrent acts of the Legislatures of the States of New York and New Jersey should be first approved and ratified by an act of Congress.

Conclusions and Recommendations.

Based upon the commission's own researches during the past eighteen months, and judging from the experiences of other localities, so far as conditions are similar, together with reports along allied lines by other investigators, the New York Bay Pollution Commission concludes as follows:

1. It unhesitatingly protests against the consummation of the present plan of construction as outlined by the Passaic Valley District Sewerage Commission.

2. It recommends that the Legislature authorize the Governor of the State of New York to appoint a Metropolitan District Sewerage Commission. This commission should continue similar examinations to those conducted by the New York Bay Pollution Commission and should thoroughly investigate the questions from engineering and economic standpoints, and make preliminary surveys for, and estimates of cost of, a comprehensive system, for ocean disposal of the sewage of the whole or the greater portion of the districts in both New York and New Jersey which are naturally tributary to New York Bay and adjacent waters. Such act of authorization should include a request that the State of New Jersey appoint a similar commission to work conjointly with that representing New York; the two commissions to cooperate in the investigations and
32 recommendations as to a comprehensive scheme of ocean disposal for the district and to outline a course of procedure for later authoritative action by the two States respectively

and the Congress of the United States. This commission ought to be provided with adequate funds for examinations, surveys, analyses, plans, etc.,—form for such bill presented herewith as Appendix 8.

In the event of the State of New Jersey pressing the construction of the proposed Passaic Valley sewer as planned, if such be authorized by constitutional legislation, the commission would recommend:

3. That the Attorney-General of the State of New York be authorized and directed to bring an action in the Supreme Court of the United States against the State of New Jersey and the Passaic Valley District Sewerage Commission, upon his attention being called to any act of said State of New Jersey, or said sewerage commission, towards carrying into effect the construction of said proposed sewerage system.

In closing, the New York Bay Pollution Commission wishes to express its thanks to the many (Appendix 11) who have been of assistance to it in freely giving of their time and data, and to the few whom the commission has retained for special services, which have been rendered in fuller measure than the direct recompense alone could have required.

Respectfully submitted,

DANIEL LEWIS, *Chairman;*
OLIN H. LANDRETH,
GEORGE A. SOPER,
MYRON S. FALK,
LOUIS L. TRIBUS, *Secretary,*
Commissioners.

March 31, 1905.

33

APPENDIX 1.

Tidal and River Flow.

By Commissioner Myron S. Falk.

It is impossible to obtain exact figures concerning the tidal flow phenomena of the lower Hudson river and New York Bay, but it is probable that a quantity of water not far from twelve to thirteen billion cubic feet enters the upper bay with each tide. Of this quantity, the relative proportions may be taken as follows:

4,250 million cubic feet passing into the East river.
6,750 million cubic feet passing up the Hudson river.
1,750 million cubic feet passing into Kill von Kull.

12,750 million cubic feet total.

These figures are of interest when taken in connection with the areas of the various tidal basins. The tidal area of the Passaic and Hackensack rivers, Newark bay and Kill von Kull comprises about

14.2 square miles. The tidal area of the upper bay is 21.6 square miles, and that of the East River 4.5 square miles; that of the Hudson river can be estimated only with difficulty as the tidal action is noticed at different periods of the year nearly all of the way to Albany.

Path of the Ebb Tide.

The ebb tide coming down the Hudson meets the ebb tide coming eastward out of the Kill von Kull, and both reach in and strike Staten Island between Stapleton and Clifton at a point dis-
34 tant about three to four miles from Robbins Reef light. The tide, then, makes along the shore and traveling along the beach makes Fort Wadesworth. At the same time there is also an ebb coming from the Arthur Kill and Raritan river which, striking the main tide from the Narrows tends to throw it to the eastward again. In calm weather the force of the main tide through the Narrows may reach as far as Swinburne Island and Orchard Shoal, although all winds tend to deflect the current.

Path of the Flood Tide.

The first effect of the flood tide through the Narrows is to strike the shore of Staten Island a little north of the point where the first effect of the ebb is felt; the second effect of the flood is to strike into the flats of the upper bay and to the west of Robbins Reef; the third, is to flow into the Kill von Kull; and the fourth and final effect is to flow up the Hudson river. After the first action of the flood is felt, the tide also travels up on the Brooklyn side of the bay. It is probable that in calm weather the maximum effect of the flood tide is felt on the northwest side of the bay.

General Facts.

The tidal ebb is detected five or six miles from the outer face of the bar, sometimes even outside of Sandy Hook lightship, but there rarely seems to be any concentration of its effects. As gathered from the Government reports, the maximum ebb velocity of the current at the Narrows is 1.5 knots, and the maximum flood 1.2 knots. In the Hudson off Thirty-ninth street these figures are respectively 2.7 and 2.0 knots, and in the East river off Twenty-third street 2.0 and 1.8 knots. Estimating a constant velocity of discharge
35 during the various tidal periods of the day the average ebb velocity at the Narrows would reduce to 1.61 miles per hour; the average flood velocity to 1.48 miles per hour.

The following figures furnish data upon which may be based the computations for determining the dilution of sewage emptying into New York bay or its vicinity; they are taken from the Report of the United States Coast and Geodetic survey for 1886, (page 36):

TABLE I.

Epitome of Results for Discharge.

June 25, 1886.

	Cubic feet.
East river (Nineteenth street):	
Ebb (westerly)	4,454,937,257
Flood (easterly)	4,007,175,676
Excess of ebb	447,761,581
Hudson river (Thirty-ninth street):	
Ebb (southerly)	6,996,678,413
Flood (northerly	6,225,985,545
Excess of ebb	770,692,868
Kill von Kull (West New Brighton):	
Ebb (toward the harbor)	1,790,103,372
Flood	1,712,415,362
Excess of ebb	77,688,010
Narrows:	
Ebb (seaward)	13,819,895,144
Flood	12,703,616,481
Excess of ebb	1,116,278,663

86 It would seem that a verification of the above results might be obtained by finding the sum of the products obtained by multiplying the area of each tidal basin, by the mean rise of the tide in said basin; the following figures furnish such a check. The computations were made in 1884, and have been taken from papers on file in the office of Col. Chas. R. Suter, Corps of Engineers, Army Building, New York City.

TABLE II.

	Tidal area in square feet.	Tidal area in square miles.	Mean range of tide in feet.	Tidal prism in cubic feet.
Upper Bay	601,824,505	21.6	4.4	2,888,757,624
Kill von Kull	68,072,219	2.4	4.6	313,132,206
Newark Bay	235,484,775	8.5	4.8	1,130,326,920
Passaic River	26,446,126	0.95	4.6	121,652,179
Hackensack River	66,765,580	2.4	4.8	320,474,786
East River (to Hell Gate)	126,309,810	4.5	4.4	555,763,164
Total				5,330,106,879

It is proper to note that in this table the northern boundary of the Upper bay is given by a line drawn from the most southerly point of New York City across the mouths of the Hudson and East rivers to the nearest point of land on the opposite shores; the western boundary by a line drawn from Constables Point across the Kill von Kull to the nearest point of Staten Island shore, and the southern boundary by a line drawn across the Narrows, from Ft. Tompkins light to the nearest point of Staten Island shore. It is not stated, from the papers on file, whether these areas are measured to the bulkhead lines or pier head lines of that time; this will cause no material error, however, even if these lines should have suffered change.

There must also be added to the total amount of tidal prism of Table II, the tidal prism of the Hudson river. The tidal area of the Hudson river, from its mouth to Poughkeepsie, comprises 2,-518,740,000 square feet; from its mouth to the State Dam at
37 Albany 3,789,820,000 square feet; but since the average tidal rise is rather difficult to obtain, as the Hudson is occupied by two tides at one time in different portions of its length, the following figures are believed to furnish sufficiently accurate results.

From the Coast Survey Report of 1858 (page 118), the discharge at the

Close of wet season (June 1)	6,038,000,000 cu. feet.
Close of dry season (September)	3,360,000,000 cu. feet.
Mean	4,699,000,000 cu. feet.

From observations from the same source in October, 1872, the flow (found nearly equal for "in" or "out" flow) was found to be 4,511,000,000 cubic feet and from Table I, above quoted, the ebb flow was found to be 6,997,000,000 cubic feet, and the flood 6,226,-000,000 cubic feet. An average of 5,000,000,000 cubic feet is probably correct and would correspond to an average rise of the tide between New York and Poughkeepsie of about 2 feet.

By adding these 5,000,000,000 cubic feet to the total of Table II, a reasonable check is furnished to the figures of Table I (assuming in Table II no entry of water into Newark bay, etc., by way of the kills).

It seems proper, then, to estimate the quantity of water which enters the bay with each tide at between 12 to 13,000,000,000 cubic feet. How much of this is available for the dilution of the sewage to be emptied into the bay at one point by the State of New Jersey, is questionable.

The following figures relating to the fresh water discharge of the Hudson river, were found in Col. Suter's office; they are believed to have considerable value:

Area drained into lower New York bay..... 16.335 square miles
Average rain fall per year at Albany..... 38.73 inches

38

Average rain fall per year at Ft. Hamilton... 39.57
Average rain fall per year at Ft. Columbus... 43.32 } 41.923 inches
Average rain fall per year at New York city... 42.88

Area affected by Albany gauge..... 11,410 square miles
Area affected by mean New York gauge..... 4,925 square miles

Rain fall per second, Albany area..... 32,555 cubic feet
Rain fall per second, New York area..... 15,210 cubic feet

Total Albany and New York areas..... 47,765 cubic feet

Assuming five-tenths of this drained into lower New York bay, furnishes 23,883 cubic feet per second, or, 1,031,745,600 per twelve hours. Any other ratio than five-tenths, could easily be used.

The following data, relating to the timing of currents, has been taken from Bulletin No. 8, Second Edition, U. S. Coast and Geodetic Survey.

Currents—New York Bay and Harbor.

Subject.	Location. Narrows.
Time of high-water slack after high-water at Sandy Hook	Hr. Min. 2 00
Duration of slack	Min. 15 to 30
Time of maximum ebb after high-water at Sandy Hook	Hr. Min. 4 30
Maximum ebb velocity	Knots. 1.5
Time of low-water slack after low-water at Sandy Hook	Hr. Min. 2 30
Duration of slack	Min. 15 to 30
Time of maximum flood after low-water at Sandy Hook	Hr. Min 5 12
Maximum flood velocity	Knots. 1.2

Remark.

In the Narrows both the ebb and flood currents appear first on the east side.

Subject.	Location. Hudson River off 39th street.	East River off 23d street.	East River off Old Ferry Point.
Time of high-water slack after high-water at Governors Island	Hr. Min. 3 08	Hr. Min. 1 54	Hr. Min. 1 16
Duration of slack	Min. 40 to 55	Min. 4 to 8	Min. 20
Time of maximum ebb after high-water at Governors Island	Hr. Min. 6 17	Hr. Min. 4 30	Hr. Min. 4 14
Maximum ebb velocity	Knots. 2.7	Knots. 2.0	Knots. 1.4
Time of low-water slack after low-water at Governors Island	Hr. Min. 3 03	Hr. Min 1 37	Hr. Min. 1 02
Duration of slack	Min. 35	Min. 4 to 8	Min. 18
Time of maximum flood after low-water at Governors Island	Hr. Min. 5 43	Hr. Min. 4 24	Hr. Min. 2 42
Maximum flood velocity	Knots. 2.0	Knots. 1.8	Knots. 1.6

Remark.

In the path of the Hudson, from the Narrows to the Tappan Sea, it is running flood 15 feet below the surface fully an hour before the turning from ebb to flood at the surface.

39 The following table, relating to direction and velocity of currents in New York bay and harbor, has been taken from Bulletin No. 3, (1888) U. S. Coast and Geodetic Survey, page 8.

Lunar hour.	Sandy Hook Bar.	The Narrows.	Kill von Kull.	Hudson River, 42d street.	East River, 10th street.	East River, Old Ferry Point.
	Feet per second.	Feet per second.	Feet per second.	Feet per second	Feet per second	Feet per second
O	S. 3.50	S. 3.20	E. 2.00	S. 2.09	S. 4.14	W. 1.25
I	S. 2.35	S. 2.75	E. 1.74	S. 4.84	S. 4.36	W. 0.90 Surface. E. 0.95 Bottom.
II	S. 2.16	S. 2.50	E. 1.53	S. 5.10	S. 2.64	W. 0.85
III	N. 0.30	Surface. S. 2.38 Bottom. N. 1.01	W. 0.61	S. 4.09	S. 1.80	E. 1.45
IV	N. 2.08	Surface. S. 1.55 Bottom. N. 1.20	W. 1.90	Surface. S. 2.50 Bottom. N. 1.08	N. 2.98	E. 1.75
V	N. 2.54	N. 1.00	W. 3.07	Surface. S. 0.91 Bottom. N. 1.91	N. 3.73	E. 1.95
VI	N. 2.53	N. 2.20	W. 2.45	N. 2.25	N. 3.88	E. 2.20
VII	N. 2.50	N. 2.20	W. 2.11	N. 3.67	N. 3.67	E. 2.05
VIII	S. 2.00	N. 2.10	Surface. E. 0.82 Bottom. W. 0.10	N. 3.17	N. 2.90	E. 1.10
IX	S. 1.98	N. 0.88	E. 1.71	N. 2.33	N. 1.69	W. 1.07
X	S. 2.33	S. 0.81	E. 2.32	N. 1.08	S. 3.60	W. 1.00
XI	S. 3.48	S. 2.10	E. 2.16	Surface. S. 0.74 Bottom. N. 0.65	S. 3.70	W. 2.00

E. signifies East.
W. signifies West.
N. signifies North.
S. signifies South.

Currents.

To determine exactly the motion of the water in the bay, it would be necessary to measure velocities of flow, not only at sections separated by horizontal distances, but also at sections separated by vertical distances; furthermore, such observations would be necessary for every single stage of the tide, both ebb and flood. As far as the writer knows, complete investigations of this kind have never been made, although the U. S. Coast and Geodetic Survey reports* contain tables showing velocities measured either along horizontal or vertical lines,
40 but not along both at the same time. Of these measurements, moreover, none is later than 1888, and various building operations occurring since that time, such as the cutting through of the Harlem ship canal, building of piers, etc., would probably render those results of comparatively little value. It seems, therefore, ad-

* See Appendix 8, report for 1871.
See Appendix 10, report for 1876.
See Appendix 15, report for 1887.

visable, except for the preceding general tables, to appeal to the personal opinions of men familiar with those matters.

The general average velocity of the currents is easily obtained; it is necessary only to divide the ebb or flood flow by the cross-section of the corresponding channel. For instance, the area of cross-section at the Narrows is 271,480 square feet; the average ebb velocity, using the figures of Table I, would then be 1.61 miles per hour, assuming that the ebb discharge for six hours would be constant; similarly, the flood velocity would average 1.48 miles per hour. Since there are times of no velocity, it is evident that the maximum velocities will at times greatly exceed these average velocities.

The cross-section of the Harlem river at Thirty-ninth street, contains approximately 173,000 square feet; the average ebb velocity would then be 1.26 miles per hour, and the flood velocity 1.13 miles per hour.

One matter of considerable importance is the question of the under-run of the salt water below the fresh water of the Hudson. The difference in specific gravity between these two waters may be as high as 2½%, and there is thus an obvious tendency for the salt water to force itself up the river for a considerable distance and to remain stagnant while fresh water follows its way down to the sea.

This tendency is probably more marked at times of low
41 water in the river. It seems proper to consider, then, whether the sewage which is discharged into the salt water may not, at various portions of the year, be stored in the pot-holes and basins of the river.

42 ## Appendix 2.

Present Sewage Pollution in New York Harbor.

By Commissioner Louis L. Tribus.

Having been assigned to the investigation of the present sources of pollution of New York harbor, I would report as follows:

I have consulted with the officials having knowledge concerning, or direct charge of, the sewerage system in each of the boroughs of the city of New York, and each of the municipalities adjoining New York Harbor and its estuaries, from the north side of Yonkers, southward, and have secured from them much of the available information as to the situation of sewers and the estimated outflow therefrom.

Whereas the great majority of sewers emptying into these waters carry both sanitary and storm flow, it may be considered that sanitary or dry weather discharge alone particularly requires our consideration, for its peculiarly polluting influence on the waters of the harbor. While at times of storm there is a great washing into the harbor of street refuse, the dilution is at once so great from the storm flow itself and in general the storms are so infrequent that we scarcely need to consider this amount of material, though

exceedingly filthy in itself, as being a serious menace to health or likely to create a permanent nuisance.

The suspended matters in the sanitary flow alone, however, if weighed dry, probably nearly equal 1,000 tons daily, surely a quantity worth anxious thought.

43 The whole territory for a radius of twenty miles from New York City Hall may be called the New York Metropolitan District, as the interests of practically all portions within that district are nearly identical, the manufacturing establishments, stores, offices and homes of those whose interests center in New York city; consequently, I would use the city's name as indicating the whole district noted, even though many municipalities be included and in two different states.

It may not be generally appreciated that this district is one of the largest manufacturing communities of the world and with variety of products almost beyond enumeration, so that the wastes carried through the sewers are equally diverse in character. It should be noted that practically all wastes other than garbage, rubbish and ashes reach the sewers, being carried thereto and therein by an abundant flow of water. While water in itself is a cleansing element, it is so much more convenient a method for the disposal of wastes than others, that the percentage of wastes is actually increased by its use.

Leaving out of consideration the storm water flow, there remains for the constant daily source of sewage pollution, the water borne house and factory wastes; consequently, the quantity of water used in the community is probably the safest estimate and, in fact, the only estimate which can well be presented, to indicate the amount of daily sewage.

The following table has been prepared showing the communities along the shores of New York harbor, the particular body of water into which their sewers empty, the respective estimated populations as of the year 1904, and the estimated daily discharge of sewage in million gallons, based on water consumption. The sewer outlet outlet numbers refer to numbers which will be found upon the map accompanying the main report of this commission.

44 *Approximate Daily Sanitary Sewage Discharge Into New York Harbor.*

Community.	Discharging into—	Sewer outlets. Numbers on map.	Estimated population.	Sanitary flow in million gallons per 24 hours.
Yonkers	Hudson River	330 to 341	56,000	6
New York (Manhattan)	Hudson River	1 to 53	823,000	82
New York (Manhattan)	Harlem and East Rivers	54 to 158	1,234,000	124
New York (The Bronx)	Harlem and East Rivers	197 to 212	297,000	30
New York (Queens)	East River	213 to 236	147,000	15
New York (Queens)	Jamaica Bay	Not numbered	53,000	5
New York (Brooklyn)	East River	159 to 183	920,000	92
New York (Brooklyn)	Upper Bay	184 to 189	271,000	27
New York (Brooklyn)	Lower Bay	190 to 193	40,000	4
New York (Brooklyn)	Jamaica Bay	194 to 196	122,000	12
New York (Richmond)	Kill von Kull	242 to 260	35,000	4
New York (Richmond)	Upper Bay	261 to 278	20,000	2
New York (Richmond)	Lower Bay	Not numbered	8,000	1
New York (Richmond)	Arthur Kill	239 to 241	12,000	1
W. New York, Weehawken, Union, West Hoboken, Hoboken, Jersey City	Hudson River	279 to 305	334,000	33
Jersey City	Upper Bay	306 to 308	23,000	2
Bayonne	Upper Bay	309 to 311	15,000	1
Bayonne	Kill von Kull	312 to 315	27,000	3
Elizabeth and S. Orange system	Arthur Kill	342 to 347	91,000	9
Perth Amboy	Arthur Kill	316 to 329	22,000	2
Totals			4,550,000	455

In the report of the Passaic Valley District Sewerage Commission as presented to the New Jersey Legislature at its session in 1903, it is stated that the plan of the commission contemplates the ultimate construction of a sewer system which would pour into New York harbor nearly 350,000,000 gallons of sewage per twenty-hour hours, though it is not contemplated to execute the whole plant at present. The population to be provided for is estimated at from over 500,000 now to 1,600,000 ultimately. Taking the estimated proportions of the total sewage to total population, the plan would contemplate a debouchement, as soon as the sewer system could be constructed, of upwards of 100,000,000 gallons per twenty-hour hours.

Another large New Jersey sewerage district, though fortunately not so densely populated, is already draining into Kill von Kull at Elizabeth, taking the watershed to the west and southwest of the Passaic Valley district, and sewering a portion of Eliza-
45 beth, Irvington, Vailsburg, South Orange and West Orange. The estimated flow is, however, comparatively small, being from 5,000,000 to 8,000,000 gallons per twenty-four hours, based on dry weather conditions.

It may be noted that the plan of the Passaic Valley District Sewerage Commission, if carried out, would not introduce into the waters of New York a total flow more than would reach it by the ordinary

present routes, because all of the districts proposed to be relieved by said systems now sewer into adjacent streams which empty in turn into Newark bay, thence into Kill von Kull and Staten Island sound, from which the flow passes into respectively the upper and lower New York bays. The difference is, however, that at present, Newark bay, and to some extent the tributary streams, acts as a great settling basin, so that most of the heavier matters are deposited there and save the main harbor from the task of assimilating them. At present such use of Newark bay is not a very serious inconvenience to many interests, but the time can be readily foreseen when the nuisance there will be very evident and intolerable, but the main question at issue is one of conserving the interests of the greater number, rather than the few.

The cause for alarm in New York and vicinity arises from the proposal to empty this large quantity of sewage at approximately one point near the center of the main harbor. The harbor as a whole may be capable of assimilating a thousand million gallons of sewage per day, if distributed at five hundred scattered points, while the same harbor might not be able to assimilate one-tenth the quantity, if poured in at five points, and the nuisance would then become not merely local, but general, as the pool of raw sewage would travel to distant points carried by tide and wind.

46 Upon others of the commission devolves reporting on such of this question. I would, therefore, report in summary that the present direct daily sewage pollution of New York harbor and its estuaries from all existing sewers is taken to be 455,000,000 gallons from something over 4,500,000 population, with probably from 50,000,000 to 100,000,000 gallons more entering through Newark bay.

47 APPENDIX 3.

Sanitary and Bacteriological Examinations and Fisheries and Industries Affected by Pollution of New York Harbor.

By Commissioner George A. Soper.

The question as to the quality of the water and shellfish of the harbor was one which had to be studied largely by means of analyses, while that relating to the industries required the collection of statistical data and information from those who had moneyed interests connected with the bay.

No attempt was made to make the examination of the waters and shellfish exhaustive, although a comprehensive plan for determining the quality of the water in all parts of the bay and rivers in the neighborhood of New York would doubtless have produced results which would have been of much scientific interest. Owing to the small appropriation which was available for the analyses, only the simplest methods could be used and the number of analyses had to be kept as low as possible.

The value of this study of the quality of the water of the bay had been greatly increased by the fact that results of analyses which have been made for others, of the water of the Hudson river and certain other waters, have recently been published in official reports. Among these reports may be mentioned the report of the commission on an additional water supply for the city of New York, 1903; the report of the committee on the Charles river dam, Boston, 1903; the report of the Massachusetts State Board of Health upon the discharge of sewage into Boston harbor, 1900;
48 and the report of the Metropolitan Sewerage Commission upon a high level gravity sewer for the relief of the Charles and Neponset river valley, 1899. Some older documents relating to New York bay have also been useful, notably, Appendix 15, of the U. S. Coast and Geodetic Survey and a pamphlet issued by the Chamber of Commerce of the State of New York on the harbor of New York; its condition, May, 1873.

Accurate information concerning the industries which might be affected by pollution of the bay have been difficult to obtain, reliable statistics being lacking in some cases and estimates made by the Government, State and local authorities differing materially. Wherever it was not possible to reconcile the figures, the most conservative data have been adopted. Information of a statistical character relating to the industries of the bay has been courteously furnished by the U. S. Census Bureau, the U. S. Commission on Fish and Fisheries, the U. S. Steamboat Inspection Service, Bureau of Shell Fisheries of the Forest, Fish and Game Commission of New York State and by many private persons connected with the oyster and transportation business in the vicinity of New York. It is a pleasure to make acknowledgment here of the many favors received from these and other sources.

3—Present Chemical and Bacteriological Condition of the Harbor and Fisheries.

A—Bacterial Evidence of Pollution:—Water.

The bacterial analyses made by the commission, although not numerous, show that the water of the bay is polluted to an extent which, though not great, is at least measurable. About 50 samples of water were taken from the bay at many points between
49 the Battery and Coney Island on the one hand, and the Battery and Raritan bay on the other. These were analyzed with the result that the colon bacillus, an invariable accompaniment of sewage, was nearly always found according to the "presumptive" test.

For the purpose of the analyses, the water was collected in prepared and sterilized bottles by a person trained in such work. After filling, the bottles were immediately carried to the Mt. Prospect Laboratory, Brooklyn, and were examined, as a rule, within two hours of the time when they were collected. In the examinations for the bacillus coli communis, specimens of the water measuring

.1 cubic centimeter, 1 c. c. and 10 c. c. were taken from the bottles and mixed with fermentation broth in Smith tubes, substantially as indicated in the report of the State Board of Health of New York for 1892, p. 712. These tubes were then incubated at 37 deg. C., for 48 hours, or in case of negative results, longer. If colon bacilli were present, they would form gas which would then be analyzed. All of the laboratory work was done under the personal supervision of Mr. Daniel D. Jackson, sanitary chemist and biologist, except a few specimens which were shipped to the Bender Hygienic Laboratory, where they were examined under the supervision of Dr. R. M. Pearce, director.

Some of the samples of water which were sent to the laboratory in Brooklyn were examined for the number of bacteria of all kinds which they contained. The medium used for this bacterial work was nutrient gelatin, prepared according to the methods recommended by the laboratory section of the American Public
50 Health Association, and customarily employed by the analysts of the Department of Water, Gas and Electricity of the city of New York. All of this laboratory work was done in duplicate.

When the colon bacillus was believed to be present, the result of the examination was reported as plus, or simply +. When no evidence of this germ was found the result was reported as negative, or, for convenience, 0.

In interpreting the results, presumptive evidence of the presence of the colon bacillus in each of the three tubes, containing .1 c. c., 1 c. c. and 10 c. c. of water respectively, was taken to be evidence of pollution; no coli in .1 but a positive result with 1 and 10 was taken to mean probable evidence of pollution; coli in neither .1 nor 1, but a positive result with 10 was not regarded as sufficiently significant for any conclusion. These I regard as fairly conservative standards for use under the circumstances.

The following table shows the results which were obtained with the first series of samples taken.

Table 1. Results of examinations of the water of New York bay. The samples were collected along the route of the Iron Steamboat Company, from Pier 1, at the Battery, down the main ship channel of the Upper bay, through the Narrows to Coney Island. The samples were taken between 10 and 11 A. M., on the ebb tide, and between 4 and 5 P. M., on the flood tide. High water occurred at Governor's Island at 5:40 A. M. and 6:07 P. M. The winds were fresh, northeast to south, with a maximum velocity of 17 miles per hour. All of the samples were clear and practically odorless. The date was June 11, 1904.

51

Map No.	Point of collection.	Bacteria per c. c.		Tests for B. Coli.					
		Ebb tide.	Flood tide.	Ebb tide.			Flood tide.		
				0.1	1.0	10	0.1	1.0	10
1	North River at head of Pier 1	45,300	21,300	+	+	+	+	+	+
2	South of Liberty Island	28,000	15,600	0	+	+	+	+	+
3	Near Robbins Reef	24,500	16,300	0	0	+	0	+	+
4	Narrows	20,100	8,900	+	+	+	0	0	0
5	Off Gravesend Bay	27,900	12,900	0	+	+	+	+	+
6	South of Sea Gate	7,900	1,810	0	+	+	0	0	0
7	Iron Steamboat Co.'s Pierhead, Coney Island	6,200	1,900	+	+	+	0	+	+

This table shows that the number of bacteria diminished with some regularity from the Battery to Coney Island, excepting in the samples taken off Gravesend bay, where local sources of pollution exist. The tests for coli are less convincing, but indicate an improvement at the Narrows and at Sea Gate over the Upper bay. The fact that coli were more often found at Gravesend and Coney Island than in some places where their presence would be more expected suggests that local sources of contamination exist in these neighborhoods. On the whole the water of the incoming tide better than the water of the outgoing tide.

Analyses of harbor waters were continued in October with the object of learning something of the quality of the water along the Staten Island and Long Island shores and over the oyster beds which are situated along the west shore of the Lower bay. The results of these bacteriological examinations are given in the tables which follow:

Table 2. Results of examinations of water taken from various points between St. George and South Beach, Staten Island. The samples were collected from the ends of piers and docks along the shore, on October 17, 1904, between 12.25 and 3.40 P. M., toward the end of the flood tide, through slack water and the beginning of the ebb. The tide was high at Governor's Island at 2:47 P. M., and at the Narrows 25 minutes earlier. The wind was light, to fresh, 52 with a maximum velocity of 13 miles per hour; in direction, southwest and west.

Map No.	Point of collection.	Bacteria per c. c.	Tests for B. Coli.		
			0.1	1.0	10
8	St. George, end of east pier	28,400	+	+	+
9	Tompkinsville, end of south pier	14,000	0	+	+
10	Stapleton, Yacht Club dock	22,000	+	+	+
11	Between Stapleton and Clifton	12,800	0	+	+
12	Rosebank	9,300	0	0	+
13	Narrows above Fort Wadsworth (¾ mile)	5,440	+	+	+
14	East of Fort Wadsworth	5,250	0	+	+
15	South of Fort Wadsworth, (¾ mile)	6,500	+	+	+
16	South Beach, upper end	5,900	0	0	+
17	South Beach, middle	6,800	+	+	+

Table 2, when interpreted by the aid of other information, affords an instructive illustration of several matters which are of special importance in this investigation. The north side of Staten Island from the Narrows to St. George is provided with sewerage systems which discharge the sewage of 20,000 people into the waters of the Upper bay along this shore. When the samples of water were taken for examination, the current was running from east to west along the shore carrying an increasing load of sewage with it. This is admirably shown by the analyses, which indicate a decidedly polluted condition of the water of St. George and a progressive reduction in its impurities from this point to the vicinity of the Narrows. The nearest sewer outfall to the Narrows is near where sample 13 was taken, and beyond this point the number of bacteria and prevalence of coli are fairly uniform. The quality of water in the samples from 14 to 17, inclusive, is probably a fair indication of the quality of the water which occupied the Lower bay at the end of the flood tide.

Duplicates of samples 8, 9, 12 and 15 were sent to the Bender Hygienic Laboratory, for analysis. The results reported from this laboratory in connection with these and other samples have not always checked with the results reported by Mr. Jackson, the
53 disparity being accounted for on the assumption that the bacterial character of the waters changed during the three to six days which elapsed between the collection and analysis of the samples in the Bender Laboratory. The laboratory methods were not precisely alike. Instead of using fractional specimens of the water for examination, five Smith tubes were inoculated with 1 c. c. each at the Bender Laboratory. No germs of the coli type *was* found in any of them.

In order to investigate the quality of the water of Gravesend bay samples were collected in that part of the Lower bay on October 20, 1904. Previous analyses indicated that the water in this section was polluted, and as the bay is known to receive the sewage of about 40,000 people, and is used to some extent for the growing of clams and oysters, particular interest attached to the examinations. The results of the analyses are given in table 3.

Table 3. Results of examinations of water taken from various points between Fort Hamilton and Sea Gate, in Gravesend bay. The samples were collected from a boat along shore, October 20, 1904, between 1:45 P. M. and 3:45 P. M., through the middle of a rising tide. The tide was high at Sandy Hook at 4:52 P. M., and at the Narrows at 5:22 P. M. The wind was light to fresh, east to south, with a maximum velocity of 13 miles per hour.

Map No.	Point of collection.	Bacteria per c. c.	Tests for B. Coli. 0.1	1.0	10
18	Fort Hamilton, 100 feet south	6,480	+	+	+
19	Fort Hamilton Beach, 100 feet S. of W. end	3,360	0	0	0
20	Fort Hamilton Beach, 100 feet S. of E. end	3,180	0	0	+
21	Off Field and Marine Club, 20 feet from raft	2,900	+	+	+
22	100 feet off Avoca Villa pier	4,900	+	+	+
23	150 feet off beach below Captain's pier	7,500	+	+	+
24	100 feet off Pier of N. Y. Canoe Club	4,380	+	+	+
25	75 feet off Public Camp Ground	8,600	+	+	+
26	Opposite Coney Island, 300 feet from shore	5,700	0	0	0
27	Opposite Coney Island, half way across bay	8,800	+	+	+
28	North of Pier of Atlantic Yacht Club	8,500	0	+	+
29	Opposite Sea Gate, 200 feet north	8,200	0	0	+
30	Opposite Sea Gate, 500 feet north	8,900	0	0	+

Table 3 indicates that the water along practically the whole shore of Gravesend bay is polluted. More than half the examinations for coli resulted positively, even in samples of water as small as 0.1 of a cubic centimeter. The numbers of bacteria were smaller than would have been expected, in view of the known sources of pollution. The coli results for 20 can hardly represent the average condition of the water at the point named, for it is within but a few feet of a large sewer outfall. Altogether, the samples, although taken along the shore where the contamination ought to be greatest, do not show as much pollution as exists in Gravesend bay. The incoming tide was distinctly favorable to the purity of the samples. It is likely that Table 3 shows the best conditions which ordinarily occur.

In order to obtain a check on the analyses, duplicates of samples 19, 20, 21, 26, 29, and 30 were sent to the Bender Hygienic Laboratory at Albany. No evidence of coli was found in any sample except sample 20. In that case there were germs of the coli type found in one out of the five tubes inoculated.

A final series of samples for bacterial analysis was taken along the east shore of Staten Island on October 22, 1904. The series exhibited in Table 2 carried the observations to the Narrows, on the shore of Staten Island, and the series which is about to be described overlapped this somewhat and extended down the Lower bay to Tottenville, passing the day-summer resorts of Midland Beach and South Beach, and running over the extensive oyster beds which lie along this coast. The results of the examinations of the waters collected over this route are given in Table 4.

Table 4. Results of examinations of water taken from various points between Stapleton dock and a point off Tottenville, Staten Island, October 22, 1904. The samples were collected between 1:00 P. M. and 5:40 P. M. The tide was low at the Narrows at 12:25 and high at Sandy Hook at 6:17 P. M. The results were therefore obtained during a rising tide. There was a brisk west wind, with a maximum velocity of 30 miles per hour.

Map No.	Point of collection.	Bacteria per c. c.	Tests for B. Coli. 0.1	1.0	10
31	Stapleton Dock	7,690	0	0	0
32	Off Rosebank	6,980	0	+	+
33	Narrows, 100 feet off Fort Wadsworth	14,400	+	+	+
34	Between Hoffman Island and South Beach	6,780	+	+	+
35	Off Creek above Midland Beach	5,100	+	+	+
36	Off Elm Tree Beacon	2,300	0	0	0
37	Between Elm Tree Beacon and Great Kills	1,040	0	0	0
38	Great Kills Point	990	0	0	0
39	Great Kills	920	0	0	0
40	Great Kills, near shore	1,600	0	0	+
41	South of Great Kills	2,340	+	+	+
42	Off Latourette Point	2,620	+	+	+
43	Off Seguine's Point	1,650	0	+	+
44	Princess Bay	2,460	0	+	+
45	Lemon Creek at bridge	12,600	+	+	+
46	Lemon Creek, 500 feet above bridge	13,800	+	+	+
47	Off Red Bank, S. I.	2,560	0	0	+
48	Off Ward's Point	40,100	+	+	+
49	Between Ward's Point and Tottenville	51,300	+	+	+
50	Off Tottenville	59,700	+	+	+

A close study of Table 4, in connection with information concerning the territory over which the samples were taken, leads to the opinion that some of the results were influenced by local sources of pollution. Those at Lemon creek, Nos. 45 and 46, show the effects of drainage which enters that creek from about 2,010 acres of populated country tributary to it. Nos. 48 and 49 and 50 show pollution due to sewage from public sewer outfalls at Tottenville and perhaps more remote points above the Arthur Kill. The other 15 samples were not taken within close range of sewers, so far as is known, and therefore give a better knowledge of the effects of more distant contamination. Considered as a whole, the table may be divided into three parts. The samples from Rosebank to Midland Beach show marked evidence of pollution. From Elm Tree Beacon to beyond Great Kills the water contained but few bacteria and few
56 of the coli type. From south of Great Kills to Tottenville there was generally strong evidence of pollution.

A—Bacterial Evidence of Pollution.—Shellfish.

As will be more fully explained beyond, the cultivation of oysters and clams is carried on extensively in the waters of lower New York bay. Most of the shellfish are taken from the southeast shore of Staten Island, but some, and especially clams, are grown in that portion of the lower harbor known as Gravesend bay. To determine whether the oysters and clams grown in the bay bear any evidence of pollution, specimens of both kinds of shellfish have been collected and examined for bacteria of the coli type by means of the "presumptive" test.

The shellfish were collected by Mr. D. D. Jackson on the same trips on which he collected samples of water reported in Tables 3 and 4. They were collected by opening the shellfish with a sterilized knife and inoculating the liquid contained in the shell in por-

tions of 0.1 c. c., 1.0 c. c. and 10 c. c. in fermentation broth in Smith tubes. The laboratory process was thereafter similar to that followed in the examinations of water. All of the shellfish were taken fresh from the beds, except those from Lemon creek.

Table 5. Results of examinations for B. coli in fifty-one specimens of oysters and clams grown in the waters of lower New York bay.

Point of collection.	Date.	Number of shellfish examined.	Number of Positive Tests for Coli.		
			0.1 c. c.	1.0 c. c.	10 c. c.
Gravesend Bay, Sea Gate...	Oct. 20	6 clams.....	0	0	2
Gravesend Bay, Sea Gate....	Oct. 20	6 oysters.....	1	2	4
Gravesend Bay, Bath Beach..	Oct. 20	5 oysters.....	0	1	2
Off Elm Tree Beacon	Oct. 22	6 oysters.....	1	3	4
Swash Channel	Oct. 22	6 oysters.....	0	0	2
Great Kills	Oct. 22	10 oysters.....	0	0	1
Princes Bay	Oct. 22	6 oysters.....	0	1	2
Princes Bay, "drunk" in Lemon Creek	Oct. 22	6 oysters.....	3	5	6

For the sake of a check, six specimens of oysters from Bath Beach, Gravesend bay, and six from off Elm Tree Beacon were sent to the Bender Hygienic Laboratory, Albany. The oysters were there scrubbed with sterile salt solution and a sterile brush, after which the shell was opened with a sterile knife and the oyster and juice placed in a sterile dish. The meat was then finely divided and the supernatent milky fluid, in samples of 1 c. c. each, inoculated into 2 per cent. glucose broth in Smith tubes. The results of these tests for coli were positive in two of the six oysters from Gravesend bay and positive in five of the six oysters from off Elm Tree Beacon.

Table 5 demonstrates the very important fact that oysters which are grown in polluted water are usually themselves polluted. Yet the samples examined for this study did not always bear as much evidence of this pollution as might be expected. In view of the known pollution of Gravesend bay, a greater number of positive tests for coli might have been looked for there. The results may be explained by the fact that the shellfish in that bay are only cultivated in the least polluted localities. The oyster beds on the Staten Island shore seem to lie between two great sources of danger, one being the polluted water which passes out through the Narrows and the other being the contaminated water from the mouth of the Raritan river and the Arthur Kill. The oysters which were freest from coli came from the vicinity of the Great Kills and Swash channel—points which are well removed from local sources of pollution and apparently beyond the reach of contaminating matters from the cities. The oysters which were "drunk" in Lemon creek bear distinct evidence of the contamination of that creek.

58 B—Chemical Evidence of Pollution—Water.

The chemical analyses which have been made by ourselves and others show that the water bears chemical evidence of pollution both at ebb and flood tide, especially in the upper bay. The examinations do not warrant the opinion that the water is everywhere and at all times badly contaminated, but the chemical evidence well supports the bacterial results in showing that traces of pollution can be found after the sewage has been thoroughly commingled with the waters of the bay and traveled miles from its points of origin.

One of the best measures of pollution at the service of the chemist is the determination of nitrogen in the forms of free and albuminoid ammonia. The test for free ammonia is particularly significant for the reason that free ammonia is always present in sewage, and when found in large amounts in water, is not likely to have been derived from harmless sources.

The following figures showing the amounts of free and albuminoid ammonia which have been found in uncontaminated sea water, drinking water and sewage, are taken from a report of Mr. H. W. Clark, contained in the report of the Metropolitan Sewerage Commission upon a high level sewer for the relief of the Charles and Neponset River valleys, p. 91, a report by Mr. G. C. Whipple, contained in the report of the Commission on an Additional Water Supply for the City of New York, p. 520, and a report by Mr. H. W. Clark contained in the report of the Committee on the Charles River Dam, Boston, p. 221.

Table 6. Results of chemical analyses of sea water. (Parts per million.)

59

Point of collection of sample.	Date.	Free ammonia.	Albuminoid ammonia.	Chlorine.
Sea water	.....	.057	.124	
Quincy Bay, Massachusetts	.....	.056	.124	
Atlantic Ocean, 3 miles southeast of Sandy Hook lightship	Feb. 27, 1903	.064	.076	16.250
Off Boston lightship	Nov. 11, 1902	.012	.068	
Sewage	.....	45.4	7.5	
Good drinking water as high as	.....	.013	.16	
Hudson river at Poughkeepsie	.....	.020	.137	

Keeping these convenient standards in mind, we are prepared to examine the free and albuminoid ammonia in the water of New York bay, as shown by 14 chemical analyses.

Table 7. Results of chemical analyses of the water of New York bay. (Parts per million.)

Map No.	Point of collection of sample.	Tide.	Date.	Free ammonia.	Albuminoid ammonia.	Chlorine
1	Pier No. 1, North River.	Ebb...	June 11, 1904	.210	.100	6,550
4	Narrows	Ebb...	June 11, 1904	.120	.120	8,100
7	Coney Island	Ebb...	June 11, 1904	.170	.170	11,250
	Hudson River at 35th Street.....	Ebb...	Feb. 26, 1903	.168	.164	*7,200
	Battery	Ebb...	Feb. 26, 1903	.140	.152	*9,800
	Battery	Flood.	Feb. 27, 1903	.124	.180	*8,150
	Robbins Reef	Ebb...	Feb. 26, 1903	.144	.140	11,225
	Robbins Reef	Flood.	Feb. 27, 1903	.124	.260	11,225
	Narrows	Ebb...	Feb. 26, 1903	.132	.112	11,950
	Narrows	Flood.	Feb. 27, 1903	.144	.180	9,800
	Rockaway Bell Buoy...	Flood.	Feb. 27, 1903	.096	.088	14,850
	West Bank Light.....	Ebb...	Feb. 26, 1903	.128	.132	12,450
	Sandy Hook Light.....	Ebb...	Feb. 26, 1903	.052	.104	14,700
	Opposite Handy Hook Light	Flood.	Feb. 27, 1903	.072	.108	15,300
	Average			.129	.143	

*100 ft. off.
* "
* "

From this table it appears that the water of the bay contains about 2¾ as much free ammonia, and about 1½ times as much albuminoid ammonia, as pure sea water, and about 6½ times as much free ammonia, and about the same amount of albuminoid ammonia as the Hudson river at Poughkeepsie. Comparing this table with Table 6, it will be seen that the most polluted samples were taken from near the Battery, Robbins Reef, the Narrows and Coney Island. The figures in the last table, excepting those
60 relating to the first three samples, are taken from the report of the Commission on an Additional Water Supply for the City of New York. The same report contains data from which the following table has been made to show the ammonias in the water of the Hudson as far up as Kingston. The figures given are averages of weekly examinations made from February to August, 1903.

Table 8. Results of chemical analyses of water of the Hudson river. (Parts per million.)

Point of collection of sample.	Tide.	Free ammonia.	Albuminoid ammonia.
Newburgh	High...	.019	.126
Newburgh	Low....	.024	.140
Poughkeepsie	High...	.022	.126
Poughkeepsie	Low....	.019	.149
Hyde Park.....	High...	.024	.133
Hyde Park.....	Low....	.036	.153
Kingston	High...	.029	.131
Kingston	Low....	.029	.149
Average.....	.....	.025	.138

These figures show that the water of New York bay, as indicated in Table 7, contains nearly six times as much free ammonia and

about the same amount of albuminoid ammonia as the water of the Hudson between New York and Poughkeepsie.

B—The Effects of Tides, Currents and Other Purifying Agencies.

One of the suprising results of this investigation, as disclosed up to this point, is the fact that the tide has little visible effect in eliminating the evidences of pollution. It had always been assumed that the sewage and other organic impurities which drained into the harbor were carried away by the vast quantities of pure water
61 which came in from the sea, the sound and the Hudson river. But it is here found that there is not a great deal of difference between the quality of the incoming and outgoing currents. In some cases the currents flowing up the bay from the sea have been more polluted than those passing out on the ebb tide. It seems that, in spite of the great tidal movement, particles of sewage which are not destroyed or affected by the wind, pass back and forth indefinitely in the bay and rivers in the neighborhood of their points of origin. The action of the tide seems rather to create a diffusion and distribution of the impurities than a mechanical replacement of them by pure water.

The question of the diffusion of the water of the bay has such an important bearing on the question of the disposal of the sewage which enters it, that I have thought it worth while to collect data to show the proportions of sea water and fresh water in the bay under different circumstances.

A—Proportions of Salt and Fresh Water in New York Bay.

The commingling of the salt and fresh water is well illustrated by the records of analyses of samples of the water taken at various points in and about the harbor. For the purposes of this study the water of the ocean beyond the range of fresh water influence may be taken as averaging about 18,000 parts of chlorine per million, although it varies considerably in different parts of the sea. We may take the chlorine of Long Island sound to be about 14,000, and the Hudson at Poughkeepsie at about 1.5 parts per million.

Table 8. Proportions of salt and fresh water found at several points near the entrance of New York bay. (Chlorine results stated in parts per million.)

62

Point of collection of sample.	Date.	Tide.	Chlorine.	Approximate per cent of sea water.
Atlantic Ocean, 3 miles east of Sandy Hook Lightship	Feb. 27, 1903	Flood.	16,230	90
Opposite Sandy Hook Light	Feb. 26, 1903	Ebb...	14,700	82
Opposite Sandy Hook Light	Feb. 26, 1903	Flood.	15,300	85
Rockaway Bell Buoy	Feb. 27, 1903	Flood.	14,850	82
West Bank Light	Feb. 26, 1903	Ebb...	12,450	69
Coney Island Pier	June 11, 1904	Ebb...	18,180	100

The most striking fact exhibited by this table is the difference between the first five results and the last. The dates were widely separated, and it is probable that the first lot of samples, taken for the Commission on an Additional Water Supply for New York City, were taken after heavy rainfalls which produced freshets in the Hudson, Raritan and other rivers which empty into lower New York bay. The following tables 9 & 10 probably show more accurately the average conditions of saltness in the Lower bay.

Table 9. Proportions of salt and fresh water found along the shore of Staten Island, in the lower New York bay. The samples were collected, beginning with the one at Stapleton dock and proceeding toward Tottenville, from 1:00 P. M. to 5:40 P. M., October 22, 1904. The tide was rising, being low at the Narrows at 12:25 P. M., and high at Sandy Hook at 6:17 P. M. The wind was blowing briskly from the west with a maximum velocity of thirty miles per hour. (Chlorine results are stated in parts per million.)

Map No.	Point of collection of sample.	Chlorine.	Approximate per cent of sea water.
50	Off Tottenville	3,400	19
49	Between Wards Point and Tottenvill	3,850	21
48	Off Wards Point	5,600	31
47	Off Red Bank	13,000	72
44	Princes Bay	13,450	75
43	Seguines Point	13,300	74
42	Latourette Point	13,900	77
41	South of Great Kills	13,150	73
40	Great Kills Inshore	13,500	75
39	Great Kills	13,700	76
38	Great Kills Point	13,750	76
37	Between Great Kills and Elm Tree Beacon	13,800	77
36	Off Elm Tree Beacon	14,050	78
35	Off Midland Beach	14,000	78
34	Between Hoffman Island and South Beach	12,700	70
33	Narrows off Fort Wadsworth	12,050	67
32	Rosebank	12,350	68
31	Stapleton Dock	12,850	71

63 The first part of Table 9 shows the effects of the fresh water which enters the bay from the Raritan and Shrewsbury rivers while the last part shows the freshening effects of the outward flow from the Narrows. The water in the Lower bay beyond these influences was probably about 75% sea water.

The water in Gravesend bay was found to be somewhat less salt than that along the Staten Island shore on a day when the tide and weather permitted a fair comparison to be made between the two.

Table 10. Proportions of salt and fresh water found at several points in Gravesend bay. The samples were taken, beginning at Fort Hamilton and proceeding toward Sea Gate, between 1:45 P. M. and 3:45 P. M., October 20, 1904. The tide was rising, being high at Sandy Hook at 4:52 P. M. and at the Narrows at 5:22 P. M. The wind was light to fresh, east to south, with a maximum velocity of 13 miles per hour. (Chlorine results are stated in parts per million.)

Map No.	Point of collection of sample.	Chlorine.	Approximate per cent of sea water.
30	500 feet north of Sea Gate	12,800	71
29	200 feet north of Sea Gate	12,600	70
28	North of Pier of Atlantic Y. C.	12,800	71
27	Opposite Coney Island, half way across the Bay	12,800	71
26	Opposite Coney Island, 300 feet from shore	12,750	71
25	75 feet off Public Camp Ground	12,950	72
24	N. Y. C. Club, 100 feet off pier	13,100	73
23	Captain's Pier, 150 feet off beach	13,250	74
21	Off F. & M. Club, 20 ft. from Raft	13,350	74
22	150 feet off Avoca Villa Pier	13,250	74
20	Fort Hamilton Beach, 100 feet south of East End	13,450	75
19	Fort Hamilton Beach, 100 feet from West End	13,800	77
18	Fort Hamilton, 100 feet south	12,800	17

The water at Gravesend bay on the day when the samples reported in Table 10 were collected ranged from 70% to 77% sea water. The lower figures probably represent the effect of local dilution from Coney Island creek and upper New York bay. On
64 the whole, the salinity is remarkably uniform, the greatest difference being only about 7%.

Table 11. Proportions of salt and fresh water found at various points in the upper New York bay. The results which bear the dates February 26-27, 1903, are taken from the report of the Commission on an Additional Water Supply for the City of New York. The rest are from analyses made for the New York Bay Pollution Commission. (Chlorine results are stated in parts per million.)

Map No.	Point of collection.	Date.	Tide.	Chlorine.	Approximate per cent of sea water.
	Narrows	Feb. 26, 1903	Ebb...	11,950	66
	Narrows	Feb. 27, 1903	Flood.	9,900	55
4	Narrows	June 11, 1904	Ebb...	8,100	45
4	Narrows	June 11, 1904	Flood.	9,900	55
13	Narrows	Oct. 17, 1904	Ebb...	12,450	69
14	Narrows	Oct. 17, 1904	Ebb...	12,200	68
15	Narrows	Oct. 17, 1904	Ebb...	12,050	67
18	Narrows	Oct. 20, 1904	Flood.	12,800	71
19	Narrows	Oct. 20, 1904	Flood.	13,800	77
20	Narrows	Oct. 20, 1904	Flood.	13,450	75
33	Narrows	Oct. 22, 1904	Flood.	12,050	67
8	St. George, S. I.	Oct. 17, 1904	Flood.	8,050	45
9	Tompkinsville	Oct. 17, 1904	Flood.	9,200	51
10	Stapleton, S. I.	Oct. 17, 1904	Flood.	8,600	48
31	Stapleton, S. I.	Oct. 22, 1904	Flood.	12,850	71
11	Between Stapleton and Clifton	Oct. 17, 1904	Flood.	8,750	48
12	Rosebank	Oct. 17, 1904	Flood.	11,650	65
32	Rosebank	Oct. 22, 1904	Flood.	12,350	69
2	South of Liberty Island	June 11, 1904	Flood.	6,150	34
2	South of Liberty Island	June 11, 1904	Ebb...	6,250	35
	Battery	Feb. 27, 1903	Flood.	8,150	45
	Battery	Feb. 26, 1903	Ebb...	9,800	54
1	Pier 1, North River	June 11, 1904	Ebb...	6,550	36

In Table 11 it will be seen that the water of the Upper bay was composed of about one-third to three-fourths sea water, the rest

being land water. The proportions evidently depended upon the point where the sample was taken, and usually, to a less extent, upon the stage of the tide. In fact the action of the tide seems to have affected it but little.

But the harbor does not always contain more salt water than fresh. As early as 1856 specific gravity determinations of the water in this vicinity were made by Prof. Henry Mitchell of the
65 United States Geological Survey, and in at least two of these, one from Pier 1, North river, and the other from the Hudson at One Hundred and Fifty-second street, the proportion of sea water was less than 20%. Samples collected March 3, 1903, for the Commission on an Additional Water Supply for New York City, show that the bay on that occasion held much more fresh water than salt. As a result of analyses taken every hour from 8 A. M. to 7 P. M., the following averages were found: The tide was high at Fort Hamilton at 10:12 A. M. and 10:46 P. M.

Table 12. Proportions of salt and fresh water found at several points in upper New York bay, East river and the lower Hudson as shown by the average hourly observations of chlorine, at a time when the Hudson was discharging large quantities of fresh water. (Chlorine results stated in parts per million.)

Point of collection of sample.	Chlorine.	Approximate per cent of sea water.
Narrows	7,862	43
Battery	2,767	15
Hudson at 130th street	267	1
Hudson at Spuyten Duyvil	99.2	.5
Hudson at Alpine	21.3	.1
Hudson at Hastings	15.7	.08
East River at Brooklyn Bridge	7,435	41
East River at Blackwells Island	9,958	55
East River at First avenue	7,727	43
Harlem River at Spuyten Duyvil	433	24

Besides showing how greatly the water in the vicinity of Manhattan may be diluted by the water of the Hudson, Table 12 shows that fresh water backed up the East river, making it fresher as far as Blackwells Island, at least. Beyond that point the reduction in salinity of the Harlem river were plainly felt. Marked differences occurred in the amounts of chlorine found in the samples taken at different hours at the same points, as might
66 be expected where the salt and fresh waters were meeting and mixing actively. At one hour the water at the Narrows was only about one-quarter salt; at the Battery only about one-ninth as salt as the sea, and at One Hundred and Thirty-ninth street and the Hudson it contained only about .14% sea water.

As illustrative of the high degree of salinity which sometimes occurs at the points just mentioned the following table, 13, compiled from data obtained from the same source as the last, is useful. The samples were collected on May 28, 1903, at every hour from 8 A. M. to 7 P. M. The weather had been dry. High water occurred at Fort Hamilton at 8:48 A. M. and 9:13 P. M.

Table 13. Proportions of salt and fresh water found at several points in the Upper New York bay, East river and lower Hudson, as shown by the average of hourly observations of chlorine, at a time when the Hudson was discharging very little fresh water. (Chlorine results stated in parts per million.)

Point of collection of sample.	Chlorine.	Approximate per cent of sea water.
Narrows	13,946	77
Battery	12,517	69
Hudson — Spuyten Duyvil	7,955	44
Hudson at Yonkers	6,283	35
Hudson at Hastings	5,041	28
Hudson at Croton Point	2,379	13
Hudson at Peekskill	1,108	6
East River at Brooklyn Bridge	12,646	70
Harlem River at 125th Street	11,958	66
Harlem River at Spuyten Duyvil	8,247	46

The figures given in Table 13 show that the water at the Narrows was on this occasion three-fourths as salt as the sea; at the Battery nearly two-thirds as salt, at Yonkers nearly one-third as salt, and at Peekskill, 50 miles from the Narrows, about 6% as salt as sea water. The difference in the amount of chlorine found from hour to hour at any one station were comparatively slight, a care-
67 ful examination of the original data indicating that the mixing of salt and fresh water was not going on violently in the vicinity of New York as was the case on the day when the samples were taken for Table 12.

From these studies it is evident that the water of New York bay is not composed of fresh and salt water in any fixed proportion. It changes with the season. In the Lower bay it has been found to range from about 20% to 100% sea water according to the location of the point with reference to local sources of dilution and the amount of land water coming down the various large rivers. A fair average for the Lower bay, under ordinary conditions of weather and beyond the range of local dilution, is probably about 75%.

The water of the Narrows has been found to vary from 43% to 77% sea water, the majority of samples averaging about 65% sea water. At the Battery the samples have ranged from 15% to 69% sea water, with an average in this vicinity, under what appear to be fairly normal conditions, of about 45%.

The lower Hudson is the scene of the widest variations in the proportion of salt. In the foregoing tables it is shown that the Hudson at Spuyten Duyvil has ranged from an hourly average of 5% to an hourly average of 44% sea water for a whole day. There may be as much salt sometimes at Croton Point, as there is at others at the Battery, 33 miles away. In fact the upper limit of brackish water may be found anywhere between Yonkers and Poughkeepsie. The cause of these differences is to be found largely in the rainfall, for this furnishes the land water which flows down the Hudson and tempers the salt. In the Spring, when the discharge of the river is at its height, large quantities of fresh water

force the salt water downward toward the sea; in the late
65 Summer, when the rainfall is slight and in Winter, when the tributary streams are frozen, the salt water creeps up the Hudson to a surprising distance. Between Yonkers and West Point the limit of salt is continually fluctuating. Every tide affects it here, and as the wind may raise the water of the bay more than the tide itself, every storm has an appreciable effect in advancing or retreating the line. The flow of the currents through the Narrows, East river and Hudson seems to have little influence upon the saltness of the water in those vicinities, except at seasons when the Hudson is discharging large quantities of fresh water, when the action of the tides produces a marked effect.

b—The Phenomenon of the Underrun.

So far we have considered only the quality of the water at or near the surface. There is reason to believe that the condition of the water at the bottom is somewhat different from that at the top. Owing to its greater mineral contents the water of the sea is about 2½ times heavier than fresh water, and this difference tends to keep the two apart. The sea water seeks the bottom and the river water the top of the bay and river.

The character of the water below the surface is of special interest in this investigation for the reason that salt water tends to precipitate sewage, causing a part of its solid ingredients to settle toward the bottom. Here the water is not so capable of disposing of the sewage inoffensively. Theoretically the water at the bottom should originally hold about the same amount of oxygen as the water at the surface, but as practically all of the oxygen must come from the atmosphere, the water at the bottom is not easily replenished in case of need. When sewage is disposed of in water, the oxygen of the latter is heavily drawn upon. If enough oxygen is not avail-
able for the beneficent bacteria which decompose, oxidize
90 and render it innoxious, they disappear and their place is taken by anaerobic germs which carry on putrefaction with the production of offensive odors. Examples of this kind of sewage disposal may be seen along the water fronts of New York wherever the sewers fail to discharge into an active current, a condition of affairs which has caused considerable annoyance and led to the removal of many sewer outfalls to the outer ends of the piers.

Observations begun in 1858 show that there is sometimes a layer of distinctly salt water beneath the brackish water in the Hudson for many miles above New York. Some persons believe that there are pockets and potholes in the bottom of the channel in which salt water and sewage accumulate, until a heavy rainfall causes a rush of water down the Hudson which clears them out. This deep current is called the "underrun."

The underrun of salt water may be and usually is quite independent of the surface currents. In fact it is often directly opposed to them; there are often two distinctly opposite currents one above the other, flowing at the same time. At a gauging station established by the United States Government in 1858, between

Bedloes, now Liberty, Island and Governors Island, the velocity of the underrun moving up the river was found to exceed the velocity of the surface current moving toward the sea. The daily progress of the underrun was 21 miles, at a depth of 68 feet.

It is obvious from this and from the fact that the surface water becomes more and more salt at points up the Hudson during dry weather, that the net result of the backward and forward movement of the tides, may sometimes be to carry such elements of sewage as are not assimilated up the river, and not out to sea, as
70 is commonly supposed.

The following extract from the report of Prof. Henry Mitchell, contained in Appendix 15 of the report of the United States Coast and Geodetic Survey for 1887, p. 308, gives the opinion of the Government observers on the sanitary significance of the underrun:

"It would seem that the drainage of New York city must be storing up in August and September at the bottom of the Hudson. Some simple tests for sulphides which we employed when the underrun was first discovered, indicated that the mixture of sea and river water was recent. No 'spoiled' water in the potholes of the great central channel was found. Happily for the communities along the lower Hudson, the floods and freshets occur often enough to purge the great trench above New York city of sea water and sewer water in spite of the long inland journeys which these are prone to take in late summer and autumn—and perhaps winter."

c—Capacity of the Water of the Harbor to Digest Sewage.

If the foregoing conclusions are correct, the sewage which enters the bay is not disposed of by being carried to sea, but is assimilated by the water of the bay itself. This assimilating process is one of oxidation in which the bacteria play an important part.

Experience and experiment have shown that the digestive capacity of a water for sewage depends largely upon the supply of oxygen which the water contains. If a sufficient supply is not available, the sewage putrefies, giving off offensive odors.

Compared with fresh water streams or the ocean, the conditions in New York bay are not favorable for the disposal of sewage by assimilation. The constantly changing proportions of salt are opposed to the existence of a definite and permanent fauna and flora, and the phenomenon of the underrun shows that there is an absence of the vertical currents which are necessary for a con-
71 tinued supply of oxygen to the lower depths where the precipitating properties of the salt water are apt to carry more or less of the sewage.

The amount of sewage which can safely be discharged into fresh water is not a measure of the amount which salt water can dispose of satisfactorily, the digestive capacity of salt water being much less than that of fresh. Experiments carried on recently by Harry W. Clark for the Committee on the Charles River Dam, show that salt water normally holds less oxygen than fresh water, and that putrefaction, with the production of the exceedingly offensive gas,

sulphuretted hydrogen, is likely to occur when sewage is mixed with salt water which has not a sufficient supply of oxygen to enable the aerobic bacteria to carry on their work.

The sewage which now flows into the bay enters it in the most favorable manner possible, that is, in comparatively small amounts and at a great number of points. This aids in its general diffusion, without which no effective purification could take place.

It is impossible to say how much sewage could be discharged into New York bay without saturating it, that is, causing its supply of oxygen to become exhausted so that offensive putrefaction would become general. Already there are certain restricted localities where the water is decidedly offensive to the sight as well as to the smell. There, however, the tidal currents are sufficient to promptly carry the impurities to the main channels and there disperse them, there as yet, no trouble.

The amount of organic matter discharged into the rivers and bay in the vicinity of New York is not known with exactness, but it can be approximately determined from estimates of the amounts 72 of sewage discharged and the rainfall. The quantity of sewage discharged into the waters in the neighborhood of New York has been found to be about 455 million gallons per twenty-four hours, and the amount of drainage due to rainfall, estimated on the basis of 42 inches of rain per year and a runoff of 75 per cent, over an area of about 162 miles, is about 243 million gallons. These added together make a total of 698 million gallons of drainage wastes which the rivers and harbor receive daily.

There are no data to show the composition of this drainage, but if its composition is similiar to that of Worcester, Mass., the only American city whose mixed house and street sewage have been carefully analyzed, there are 1½ tons of solid, dry sludge for every million gallons, or 1,047 tons in it all. Of this, about one-half is organic matter.

Considered as a whole, there are no indications that the bay is being taxed beyond its capacity nor that it cannot digest considerably larger quantities of sewage, provided they are added properly, that is, through a sufficient number of outlets sufficiently far apart. What would happen if a very large amount of sewage were to be discharged at a single point is not ascertainable, but there is reason to believe that it would not be disposed of without the production of conditions which would be very objectionable if not intolerable. The chief danger is that it would not commingle promptly with the water surrounding it, in which event it might be carried to inhabited shores, creep up the Hudson with the undertow, or rise to the surface and there form an unpleasant, discolored area, as now happens in the harbor of Boston.

In considering the capacity of the bay to digest sewage, careful account should be taken of the future pollution to which it 73 will necessarily be subject as a result of the increase of population of New York city and the municipalities on its shores. Accepting the estimates of Mr. John R. Freeman, who has given very close attention to this subject of population in connection with

his studies of the future water supply of New York, it appears that the population of this area will be about double that of the present time in the year 1930. If the amount of sewage increases in proportion to the population, and the rainfall remains constant, the total increase in the amount of drainage entering the waters about New York will be about 65 per cent.

C—Industries Affected by Pollution.

The industries of New York bay which stand in any danger of being injured by such pollution as now exists, or is at all likely to occur in the future, may be classified as follows:

a. Shad fisheries.
b. Shellfish industries.
c. The passenger transportation business.
d. Excursions and bathing beaches.

These will now be considered separately:

a—Shad Fisheries.

The shad fishing industry depends upon the annual migration of the shad, Clupia Sapidissima, from the sea up the Hudson river to spawn. The most important localities for shad fishing are in Westchester, Ulster, Dutchess and Columbia counties, beside which the catch in the immediate vicinity of New York, by citizens of this State, is insignficant. Still, as the fish which are caught farther up the river must all pass through the Upper bay and lower Hudson, they are to some extent exposed to such conditions as there
74 exist. The fish begin to ascend the river in early spring. Gill nets are set for them in those parts of the river which are moderately shallow, the shoal water in the Upper bay known as the Jersey Flats being one of the spots favored by the fishermen.

It is said that some shad have been caught near the entrance of the Kill von Kull which have, when cooked, tasted strongly of kerosene, and that the discharge of liquid refuse in this vicinity from large industrial establishments has been the cause. Whether this is true or not could not be verified.

The following statistics of the shad industry in the vicinity are taken from a report of the United States Commission of Fish and Fisheries for 1902, *pp.* 449.

Table 14. Yield of shad in the vicinity of New York bay and credited to citizens of New York State in 1901.

County.	Pounds of fish.	Value.
New York	3,600	$250
Kings	45,975	2,715
Richmond	118,700	6,360
Total	170,275	$9,325

When it is considered that the shad industry of New York State yielded in 1901, 3,432,472 pounds of fish, valued at $110,682, and

was greater in that year than in any year since 1888, it does not seem likely that any pollution now in sight will do this business any harm.

b—Shellfish Industries.

The upper part of New York bay once supported oyster beds which extended from Staten Island to above Newburgh. Bedloe's Island, now called Liberty Island, was known as Oyster Is-
75 land and two small reefs just south of it were called the Little Oyster Islands. The oysters occurred here naturally and were reckoned a considerable source of wealth. They were so plentiful that the public was allowed to gather them with little or no restriction, until to-day these extensive grounds have become exhausted.* At the present time the cultivation of oysters in the bay is carried on almost exclusively below the Narrows. The Jersey Flats still furnish a small amount of natural seed, but it is doubtful if any market oysters are taken there. Attempts to raise seed in the vicinity of Piermont, just above the Palisades, recently, resulted in failure.

The value of the oyster beds in New York bay below the Narrows is very large. The principal grounds are owned by the State, on the southeast shore of Staten Island, and are let out at a nominal rent to those who apply for the privilege of cultivating them. Nearly the whole shore from a point near the mouth of the Raritan river to the neighborhood of Hoffman Island is now under cultivation, the total area of the beds being estimated at nearly 30 square miles. Prominent oystermen have estimated the yield from these islands at 500,000 bushels per annum; the Bureau of Shell Fisheries of the Forest, Fish and Game Commission has estimated it at more than four times this, and the United States Commission of Fish and Fisheries has estimated the yield at about 300,000 bushels for 1901. The value of these oysters is commonly taken to be $1 per bushel, although they sometimes bring a higher price.

76 Some clams or quahogs are taken in the same localities, but the only estimate of the quantity of these shellfish is that given by the United States Commission of Fish and Fisheries, which places the annual output at 21,900 bushels.

Table 15 gives details of the oyster business in this region as given by the Government authorities.

Table 15. Extent of the oyster and clam fisheries of Richmond county, N. Y., in 1901, as given by the United States Commission of Fish and Fisheries.

---

* NOTE.—That the pollution of the waters about New York by sewage, factory drainage and garbage have also done much to destroy the natural oyster beds in this vicinity, is stated in reports of investigations of the oyster industry made in 1885–1888 by the Commissioner of Fisheries of New York State, and published as Assembly Documents No.'s 85, 1885; 28, 1887, and 37, 1888.

Items.	Number.	Value.
Persons:		
On vessels fishing	170	.....
On vessels transporting	120	.....
In shore—or boat fisheries	259	.....
Shoremen	16	.....
Total	565	.....
Vessels fishing	36	$88,900
Tonnage	477	.....
Outfit	.....	29,387
Vessels transporting	50	48,850
Tonnage	619	.....
Outfit	.....	11,847
Boats	349	42,645
Apparatus—vessel fisheries:		
Dredges	128	6,205
Tongs	40	323
Rakes	18	144
Apparatus—shore fisheries:		
Dredges	6	150
Tongs	318	2,569
Rakes	375	3,159
Shore and accessory property	.....	17,885
Total investment	.....	$252,064

Product taken.	Bushels.	Value.
Clams, hard, Public reefs	21,900	$18,485
Oysters, market, Private areas	291,841	273,617
Oysters, seed, Public reefs	8,100	3,430
Oysters, seed, Private areas	6,000	3,000
Total products	327,841	$298,532

The foregoing table does not represent the whole product of shellfish from New York bay, there being small oyster grounds and extensive clam beds in Gravesend bay, within the limits of New York city. Other localities where shellfish are taken in the vicinity
77 of New York bay, are Newark bay, Raritan river, the bend of the horseshoe, and the mouth of the Shrewsbury river. There are extensive natural seed beds in the Arthur Kill. Probably 500,000 bushels of market oysters are taken annually by citizens of New York State from the waters of the harbor within the limits of this State, and the same quantity by citizens of New Jersey from practically the same waters within the State of New Jersey.

Our analyses show that most of the oysters grown in the Lower bay are not dangerously polluted, but that those which are taken from contaminated water are practically certain to be contaminated themselves.

The oysters taken from the Staten Island beds are not always shipped direct to market, but are first taken to some convenient stream of fresh or brackish water and there allowed to remain from high to low tide. In this way the size of the oysters is greatly in-

creased. Some of these "drinking" places, as they are called, in the vicinity of New York bay are among the worst to be found anywhere. One, known as Lemon Creek, on the southeast side of Staten Island, drains a populated area of 2,010 acres and has numerous privies and other sources of pollution on its banks. Samples of water and oysters taken from the mouth of this stream have been shown by our analyses to be greatly polluted. Another, and if possible, more dangerous "drinking" ground is situated at Tompkinsville, Staten Island. The stream which furnishes such fresh water at this place affords, flows from a thickly populated area of 2,960 acres. The sewage which is discharged into the Kill von Kull on both sides of this place, within a distance of three miles, exceeds 7,000,000 gallons per 24 hours. During the season prob-
78 ably ten thousand bushels of oysters are sometimes treated here per day. Sloops come not only from the neighborhood of New York, but often from very distant points to "drink" their oysters before offering them for sale at the markets. Outbreaks of typhoid fever have been traced to oysters treated elsewhere in this way, and the "drinking" should be forbidden by law.

c—Passenger Transportation Business.

The business of transporting passengers across the bay is already large and is constantly increasing. The majority of the passengers are commuters who do business in one part of the city and live in another, or in the country, and go back and forth every day on the boats of the ferry companies.

The pollution of the bay, if unrestrained, might affect the business of these companies in two ways. The number of passengers would decrease if public health was endangered by the trip, or if the water became markedly offensive to the sight or smell. Fortunately, no amount of pollution which the growth of the cities bordering on the bay will make necessary is likely to affect the health of persons crossing the water, although it is quite conceivable that the discharge of a large amount of sewage in one spot might cause a local nuisance which would divert travel to more agreeable routes.

The extent of the transportation business in the waters about New York may be understood by the following table, compiled from data courteously supplied by the United States Steamboat Inspection service:

79 Table 16. Number of passengers carried by the principal ferries in the vicinity of New York in 1903.

Name of ferry company.	Number of passengers.	Route across.
Brooklyn Ferry Company...	33,911,317	East River.
Hoboken Ferry Company...	32,000,000	Hudson River.
Union Ferry Company.....	30,687,096	East River.
Penn. R. R. Company.....	30,337,493	Hudson River.
Erie R. R. Ferries.....	16,667,252	Hudson River.
L. I. R. R. Ferries.....	15,639,250	East River.
C. R. R. of New Jersey Ferries	10,700,862	Hudson River — New York Bay.
S. I. R. T. Ferry.....	7,929,000	New York Bay.
W. S. R. R. Ferries.....	5,873,886	Hudson River.
N. Y. and E. R. Company...	4,309,700	East River.
Nassau Ferry Company.....	2,680,000	East River.
N. Y. & S. Brooklyn Ferry Company	1,720,000	East River and New York Bay.
Fort Lee Ferry.....	1,705,659	Hudson River.
Total.....	194,161,515	

Of the total number of passengers shown in Table 16, about 8,811,000 traveled directly across the center of upper New York bay.

d—Excursions and Bathing Beaches.

For somewhat less than six months of the year excursion steamers ply about the bay and carry large numbers of passengers in search of pleasure and health. Most of these steamers have fixed destinations, such as picnic grounds and bathing beaches, but some merely sail about without landing their passengers. The total number of passengers carried by excursion steamers in the New York district in 1903 was about 2,300,000. It is obvious that any condition of the water which is capable of injuring the business of transporting commuting passengers is certain to do at least equal injury to the excursion business.

A large proportion of the people who patronize the excursion steamers do so in order that they may reach in a pleasant and expeditious manner what are called "day summer resorts." These are in reality extensive bathing beaches with hotels, restaurants and a great variety of amusement places. The largest day summer
80 resort near New York is Coney Island, with a daily attendance estimated at from 200,000 to 400,000 people. Others are Midland Beach and South Beach, on the Staten Island shore. These are all located in the Lower bay, somewhat beyond the Narrows. Millions of dollars have been invested at these day summer resorts to attract visitors and they are deservedly popular. They would suffer material loss in patronage if the water became sufficiently polluted to affect health.

Bathing is far more common in the Upper bay than is generally supposed. In the year 1903 over 3,000,000 baths were taken in the floating bath houses maintained by the city of New York on the water front.

D—Project of the Passaic Valley Sewerage Commission.

It is proposed by the Passaic Valley Sewerage Commission, acting under authority of the Legislature of the State of New Jersey, to construct a large trunk sewer which shall collect the sewage of an extensive and populous district and empty it into the waters of New York bay. The point chosen for the outfall of this sewer is about three-quarters of a mile north of Robbins Reef light, on the western edge of the main channel of the Upper bay. The discharge is to be continuous. The ultimate capacity of the sewer is to be 345,830,000 gallons per 24 hours. This is approximately 50% of the total amount of sewage from houses and streets which drains into the bay at present.

A careful examination of the published reports of the engineers whose opinions have been asked by the Passaic Valley Sewerage Commission with reference to the possibility that the proposed sewer will create a nuisance to persons or property adjacent to the
81 bay, shows that it has generally been assumed that the tides cause a more perfect flushing and cleansing than our present studies indicate. In the foregoing sections of this report we have not found that the water of the bay is renewed at every tide. Analyses have shown that there is not ordinarily a great deal of difference in the quality of the water at ebb and flood tides. Samples taken near the Narrows on the flood tide have been far from as pure as the sea. Our studies of the diffusion of the salt and fresh water in the bay lead to the conclusion that the rise and fall of the tides result largely in a backward and forward movement of the same water and that the actual renewal of pure sea and river water, except during freshets or storms, is far less than has been supposed.

In considering the possibility that the sewage of the Passaic Valley District can be discharged into New York bay without creating a nuisance, therefore, we should reject the idea that it will be promptly carried to sea and consider the probability that it can be assimilated and digested by the water of the bay in the bay and rivers about New York.

We have seen elsewhere in this report that the digestive capacity of New York bay is very large; larger than would probably be necessary for the assimilation of the sewage which will probably need to be discharged into it in the next twenty-five years. This conclusion is not based upon the assumption that sewage would be brought to the bay from communities remote from the shores of the bay, nor upon exceptional conditions such as the discharge of an enormous quantity of sewage at any particular points. Such conditions if not prevented, might easily lead to local nuisances and overcharge the water with organic matter which could only putrefy.

82 What appears to be an erroneous assumption in the reports of the engineers of the Sewerage Commission is the theory that the sewage from the Passaic Valley sewer will be rapidly diffused throughout the bay. It does not seem possible that this diffusion could be as rapid as the diffusion of smoke and vapors in the atmosphere, and we have in tall chimneys at Bayonne and Fort Lee

sufficient illustration of the fact that smoke and vapors can travel several miles without commingling with the atmosphere and disappearing from sight. Is it probable that the sewage of the Passaic Valley District would be so rapidly diffused that it would not be easy to recognize it from the decks of the boats which ply through the harbor? Precedents for the discharge of so much sewage at a single point are not numerous, but perhaps the experience of Boston may be cited as an answer.

At Deer Island, near the entrance of Boston harbor, there is an outlet of a sewer which discharges 38,300,000 gallons of sewage per day. The water near this outlet is discolored over an area of about 350 acres. When the sewage has traveled about 1⅛ miles from the outlet, which it does in about 1¼ hours, the discoloration disappears.

At Moon Island, also in Boston harbor, there is a sewer outfall which discharges 22,000,000 gallons of sewage in ¾ hour, the discharge being discontinuous and so regulated that the sewage is emptied into the harbor only during that period of the outgoing tide which is most likely to carry it to sea. The discolored area in this case is about 750 acres. Because it is not all perfectly fresh, some of this sewage is septic. It is offensive to the sight and smell over two-thirds of the discolored area.

If the conditions in Boston harbor are to be taken as an indication of what might happen in New York bay, it appears that
83 the discharge of the greater quantity of sewage which the Passaic Valley District Sewerage Commission has to deal with, would discolor about 3,000 acres or 4.7 square miles.

Setting aside, therefore, the questions of health and the ultimate saturation of the bay with organic matter, this local discoloration, with possibly the creation of offensive odors, directly in the path of ferry boats, excursion steamers and the Atlantic shipping would be a cause of serious annoyance. But it is by no means certain that the discharge of so much sewage in the centre of the tidal basin of the Upper bay would not bring about conditions injurious to the public health. The proposed outfall is within ½ mile of the pierhead line and 1¼ mile of the line of solid filling established by the U. S. Government on the New Jersey shore. It is within two miles of Staten Island and of Liberty Island, a popular point for excursions, and of Governors Island, the headquarters of the U. S. army in this district. The Brooklyn shore is about two miles away. Ellis Island, the headquarters of the U. S. Immigration Bureau, is within 2½ miles. The southern end of Manhattan is about 3¼ miles away. Immediately to the west, are the Jersey Flats comprising about 8 square miles of muddy bottom lying under about 1 to 7 feet of water at low tide. The extensive improvements of the Pennsylvania railroad are close to the proposed outfall on the north.

Summarizing the matter, it does not seem likely that the additional amount of organic matter which would be contained in the sewage which the Passaic Valley Sewerage Commission would discharge into the bay would overtax the digestive capacity of the water provided that it could be added in a way which would insure

its immediate and thorough diffusion throughout the waters of the harbor and rivers. The effect would undoubtedly be to increase the permanent effects of pollution which are already measurable and which make the waters in the vicinity of the bay less desirable than they should be for bathing and the cultivation of shellfish. But it is not believed that a complete and satisfactory diffusion of the sewage lies within the range of practical possibility. A large number of the comparatively small sewers which discharge into the bay, create local nuisances near their outfalls, and experiment shows that the disposal of sewage into water which has not sufficient oxygen to permit of its prompt decomposition by the bacteria, results in a particularly offensive kind of putrefaction. The experience of Boston is believed to furnish a fair illustration of the kind of local nuisance which could reasonably be expected if the present plan of the Passaic Valley Sewerage District Commission was carried out. The fact that the sewage at Nixon Island discharges at the surface, and at Deer Island 9 feet below the surface at high tide, while the Jersey sewer is to empty into the bay at a depth of 45 feet, seems not to have sufficient bearing upon the conditions to alter this conclusion.

Conclusions.

The studies which have been outlined in the foregoing pages have led to certain definite conclusions which, for convenience, may be briefly summarized as follows:

(1.) The effects of the present pollution of New York bay, although not great, are nevertheless measurable.

(2.) A careful study of the proportions of sea water and fresh water in the bay and rivers about New York shows that the sewage of New York city is not promptly flushed out to sea, except during freshets in the Hudson.

(3.) The water of the incoming tide is not ordinarily much purer than the water of the outgoing tide in the Upper Bay.

(4.) It is probable that most of the sewage which enters the bay is disposed of in the bay by animals and plants, chiefly the bacteria which live in this water.

(5.) The most useful effect of the tide is its production of currents whereby the sewage becomes mixed and diffused.

(6.) The drainage which now enters the bay does so in the most favorable manner possible for diffusion; that is, from a large number of outlets situated along an extensive shore line.

(7.) How much sewage and other organic matter can be emptied into the bay without killing those forms of life which now destroy it, and so creating a general nuisance, it is impossible to say. This is a matter of great importance, but its proper study requires analyses and experiments which have been beyond the reach of this commission.

(8.) Compared with fresh water streams or the ocean, New York bay is not a favorable place for the inoffensive disposal of sewage.

(9.) Should the bay become overloaded with sewage, the odors which will arise from it will be particularly offensive.

(10.) The total amount of solid matter which now enters the bay with house and street sewage, every 24 hours, is approximately equivalent to 1,047 tons of dry sludge. About one-half of this is organic matter.

(11) The bay is not likely to be polluted to such an extent that a general nuisance will occur for 25 years at least, if it is used solely for the discharge of sewage from the communities which are adjacent to its shores.

86 (12.) Long before a general nuisance is produced, local nuisances will occur, as may be seen at present to a limited extent, where sewers and drainage from industrial works empty into still, or comparatively still water.

(13.) Observations made by the U. S. Government show that a distinct current of salt water sometimes runs up the Hudson under the fresher water, without respect to surface currents, and it has been suggested that this under-run carries sewage from New York city up the river and empties it into potholes or depressions in the bed of the channel, where it remains until washed out by freshets.

(14.) The oyster beds in New York bay are almost exclusively located on the southeast side of Staten Island and Gravesend bay.

(15.) Most of the oyster and clam beds are now free from dangerous pollution, although there are some on the Staten Island shore near the Narrows and the Kill von Kull, and a few in Gravesend bay, which are nearer sewer outfalls than is proper.

(16.) Our analyses of oysters and clams show that shellfish which are grown or immersed for some hours in polluted water become polluted themselves.

(17.) The increasing amount of pollution to which the waters of New York bay are subject makes it seem only a question of time when oyster culture will be driven from this locality; but with wise and careful protection, a large part of the present oyster grounds can be kept safe for some years to come.

(18.) The almost universal custom in this vicinity of "drinking," that is, bleaching and bloating oysters in polluted streams of fresh water, places all shellfish under suspicion of being contaminated.

87 (19.) The pollution of the bay has had no visible effect upon the number of fish caught in the vicinity of New York, although petroleum and other industrial wastes appear to have occasionally affected the flavor, and consequently the value, of small catches of shad.

(20.) The transportation of passengers on ferry boats is one of the most important industries connected with the bay, the number of passengers transported in the New York district in 1903 having been 204,000,000, and the number which traveled directly across the centre of the Upper bay, 8,811,000. This business would be seriously injured if the water became offensive to the sight and smell.

(21.) Unrestricted pollution of the bay would destroy the health-

fulness and attractiveness of the parks and recreation piers which have been built by the city of New York on the water fronts for the benefit of the poor.

(22.) Excursion steamers carried about 2,300,000 passengers to bathing beaches and other day summer resorts on or near the bay in 1903. The most important of these places are located a little beyond the Narrows in the Lower bay and represent a total investment of several million dollars. The pollution of the bay will eventually injure the healthfulness and business value of these resorts, unless restricted.

(23.) The project of the Passaic Valley Sewerage Commission of New Jersey, if carried out, would ultimately empty into the centre of the upper bay 345,850,000 gallons of sewage per day from a community not adjacent to the bay.

(24.) The proposed sewer, if put into service at once, would increase the amount of house sewage and storm drainage which enters the bay by about 50 per cent.

(25.) The natural increase in population of New York and vicinity will, by 1930, increase the present amount of pollution about 65 per cent.

(26.) If the New Jersey sewer is built, the pollution of New York bay will be more than doubled in the next twenty-five years.

(27.) Since the organic matters contained in the sewage which is emptied into the bay must be destroyed by assimilation in the bay, it is evident that the discharge of so much sewage as that proposed by the Passaic Valley District Sewerage Commission must first be diffused before it can be purified. It is by no means clear that the sewage would be so diffused before reaching inhabited shores.

(28.) Precedents for the discharge of so much sewage at one point, as contemplated by the Passaic Valley District Sewerage Commission, indicate that this quantity of sewage cannot be emptied into New York bay, in accordance with the announced plans of that commission, without producing a local nuisance.

(29.) Probably the nearest approach to the conditions which might be expected is at Boston. At Deer Island in Boston harbor, the discharge of 38,300,000 gallons of sewage per day causes the water about the outlet of the sewer to be discolored over an area of 250 acres. At Moon Island, also in Boston harbor, the discharge of 22,000,000 gallons of sewage in about ¾ hour discolors about 750 acres, about two-thirds of this area being offensive to the sight and smell.

(30.) If the conditions in Boston harbor are a fair example of what would happen in New York bay, the sewage from the outfall of the Passaic Valley sewer would discolor and render more or less offensive about 3,000 acres or 4.7 square miles of the most beautiful and most traveled part of New York bay. On calm days the sleek, or thin film of grease from this sewage might reach Liberty Island, Ellis Island, Governors Island and the Battery, or Brooklyn and Staten Island.

89 APPENDIX 4.

Legislative and Documentary History of the Passaic Valley Project, and Ocean Disposal of Wastes.

By Commissioner Olin H. Landreth.

Passaic Valley Sewerage Commission.

The Legislature of New Jersey on February 26, 1896, enacted a law (being chapter 7 of the Laws of 1896) entitled "An act for the construction of a general system of sewage disposal for the Valley of the Passaic river and the prevention of the pollution thereof." This law provided for the appointment by the Governor of three citizens of New Jersey to consider the subject of the pollution of the Passaic river and for a general system of sewage disposal for the relief of the Passaic Valley. These persons were given power to employ engineering and other assistants and to report to the Legislature their conclusions, with maps, plans, methods of carrying out the work, an estimate of cost and a recommendation as to the method of apportioning the cost. The sum of ten thousand dollars was appropriated to defray expenses of this investigation.

A copy of this act in full is given on page 5, of the published report of the N. J. commission dated February 26, 1897, and forming item No. 2 of this synopsis. Governor Griggs appointed on April 21, 1896, as such commission, Messrs. Elias J. Marsh, M. D., H. C. H. Herold, M. D., and William T. Hunt, who prepared and submitted to the Legislature on February 26, 1897, their report of the Passaic Valley Sewerage Commission which forms the following item.

90 Report of the Passaic Valley Sewerage Commission Submitted February 26, 1897.

The commission organized with the following officials and advisers: E. J. Marsh, M. D., treasurer; W. D. Scott, secretary; Joseph Could, counsel; Alphonse Fteley, consulting engineer; C. E. A. Jacobsen, engineer; H. E. Abbot, A. W. Cuddleback, Robert F. Sayles, James A. Wylie, assistant engineers; Herbert B. Baldwin, chemist, and Richard N. Connolly, M. D., bacteriologist.

The report of the commission contains the individual reports of the engineers, the secretary, the chemist and the bacteriologist together with the general conclusions and recommendations of the commission including the draft of "An act providing for the purification of the rivers and streams of water within this State and to prevent the pollution of the same."

Act to Prevent the Pollution of the Upper Passaic River.

The Legislature of New Jersey enacted on March 24, 1897, (forming chapter 35 of the Laws of 1897) an act to prevent the wilful pollution of the Passaic river and the tributaries thereof above the Great Falls of the Passaic river at Paterson. This law was evidently intended to protect the purity of the potable water supply of the East Jersey Water Company and has no very important bearing on the efforts to reduce the pollution of the lower Passaic Valley.

Legislative Committee.

Owing to a strong opposition to the terms of the draft of the bill recommended by the commission of 1896 the bill was not brought up for passage but in place thereof an act was passed authorizing a committee of members of the Legislature to study the subject of and to report at the next session what should be done in the matter. The committee consisted of Senators Robert Williams, and W. M. Johnson and Assemblyman T. C. Wildman. During 1897 this committee held public meetings and listened to arguments for and against the proposed legislation. In the spring of 1898 the committee reported as a result of its labors that the whole matter ought to be studied again by a new commission and presented a bill providing for a commission of eight persons, three of whom were to be members of the original commission of 1896. The bill was passed and Governor Voorhees on Aug. 3, 1898, appointed the following commissioners: Mr. William T. Hunt, Dr. H. C. H. Herold, Dr. E. J. Marsh, Hon. John Hinchliffe, Dr. James A. Exton, Hon. Charles W. Fuller, Hon. Charles F. Harrington, and Mr. William Kent.

State Sewerage Commission.

The Legislature of 1899 on March 24th enacted a law (forming chapter 210 of the Laws of 1899) entitled "An act to prevent the pollution of the waters in this State by the establishment of a State Sewerage Commission, authorizing the creation of sewerage districts and district sewerage boards and prescribing, defining and regulating the powers and duties of such commission and such boards." This act provided for the appointment by the Governor of five citizens of the State to compose the "State Sewerage Commission," the duties of which commission are to investigate the various methods of sewage disposal and to investigate all complaints of pollution of the waters of the State and to advise as to the best methods of sewage disposal in order to prevent such pollution and to pass on, approve or disapprove of all plans for sewage disposal into the waters of the State before such systems can lawfully be built and the sum of five thousand dollars was appropriated to enable the commission to carry out the provisions of the act. The act also provided for the formation of "sewerage districts" and

the appointments of "sewerage boards" each board to comprise two members of each municipality within the district to be appointed by the governing body of each such municipality and one member to be appointed by the State Sewerage Commission. These district boards were to be considered as corporate bodies and were given powers to investigate, design, construct, maintain and operate systems of sewerage and drainage or systems of sewage disposal works or both and were given the power to condemn and appropriate lands and to issue bonds.

This act was re-enacted in a somewhat amended form by the Legislature of 1900 (forming chapter 72 of the Laws of 1900.)

It is to be noted that the functions of this State Sewerage Commission are general and are not confined to the Passaic Valley.

The first commissioners to be appointed under this act were as follows: Charles F. Harrington, Hon. John Hinchliffe, Wm. T. Hunt, Charles W. Fuller, David L. Wallace.

This State Sewerage Commission has submitted several annual reports referred to as follows:

Annual Report of State Sewerage Commission for 1899.

This report forms document No. 48 of volume V. of Legislative Documents for 1899. As no appropriation was made for the expenses of the commission no engineering investigations were made during the year, but the commission gathered a large amount of information concerning the sewerage of the cities and villages of the State on circular blanks issued by the commission. The
93 commission recommended to the Legislature that additional powers be given the commission by which they might compel the abatement of existing pollution and also recommended that authority be given to two or more municipalities to cooperate in providing sewerage and disposal. The commission also submitted a draft of a bill amending the existing law (chapter 210 of the Laws of 1899) so as to provide the above and several other proposed features.

Annual Report of the State Sewerage Commission for 1900.

This report comprises document No. 49 of volume V. of Legislative Documents for 1900. The Legislature of 1900 amended the original law establishing the State Sewerage Commission and re-enacted it as chapter 72 of the Laws of 1900. On June 4, 1900, the State Sewerage Commission adopted a resolution as follows:

Resolved, That under authority of chapter 72 of 1900 that prior to June 1, 1904, the municipalities of Paterson, Passaic, Rutherford, Newark, Orange, East Orange, Montclair, Bloomfield, Glen Ridge, Kearney, Harrison and East Newark now polluting the waters of the Passaic river with sewage, must cease to pollute the waters of the said river and make such disposal of the sewage and other polluting matter of such municipalities as shall be approved by this commission.

During the year the commission received and considered a number of complaints and petitions and passed on plans for sewerage and sewage disposal for a number of municipalities in the State. The subject of sewage disposal in Great Britain and France was investigated by Chairman William T. Hunt who inspected and reported on the system in use in London, Paris, Leeds, Manchester, Glasgow and Edinburgh. No extended engineering investigations were made by the commission during this year owing still to lack of funds.

Annual Report of State Sewerage Commission for 1901.

This report forms document No. 49 of volume V. of Legislative Documents of 1901. Governor Vorhees transferred to the commission eight thousand dollars from his emergency fund, which enabled the commission to undertake some engineering work. This work was all confined to the Passaic Valley problem as being the most important single sewerage problem in the State and consisted in the making of surveys and plans for the system of intercepting sewers extending from Paterson along Passaic river to Newark bay with plans for sewage disposal. A part of this work was undertaken by Messrs. Collin R. Wise, Robert M. Watson and William Ferguson, engineers, and the remainder by Mr. James Owen, C. E., and reports were submitted for these two divisions of the engineering work. These reports with the maps and plans accompanying them were then submitted to a board of consulting engineers comprising Messrs. Rudolph Hering, J. J. Croes and William M. Brown who examined and reported not only on the plans as already submitted, but also on alternate features. The conclusions of the board of consulting engineers were that the most efficient and economical system of disposal for the Passaic Valley from Paterson to Newark bay was a system of intercepting sewers without sewage treatment by which the entire sewage of the municipalities along the valley should be brought to New York bay. The commission also submitted a number of technical questions regarding the sewage disposal to Mr. H. W. Clark, chemist of the Massachusetts State Board of Health, and the report contains the answers of Mr. Clark on these questions. In addition to the Passaic Valley investigations the commission also considered the cases of a number of municipalities and streams throughout the State and ordered a number of municipalities to cease the pollution of certain streams at certain stipulated dates. The commission also approved during the year plans for sewerage and disposal for a number of municipalities in the State.

Annual Report of the State Sewerage Commission for 1902.

This report forms document No. 33 of Volume III, of Legislative Documents for 1902 submitted to the Legislature of 1903. The Legislature of 1902 having passed an act (chapter 48 of the Laws of 1902) establishing a separate sewer district for the Passaic

Valley and creating a commission therefor. The State commission devoted its energies to other portions of the State, placing the services of its members and the official records and material at the disposal of the Passaic Valley Sewerage Commission.

The Legislature of 1902 passed an act (chapter 49 of the Laws of 1902) which was approved March 27, 1902, providing that the Legislature might create and incorporate sewerage and drainage districts and providing for the appointment by the Governor of boards of sewerage commissioners of five residents of each such districts.

Passaic Valley District Sewerage Commission.

The Legislature of 1902 passed an act (chapter 48 of the Laws of 1902) which was approved March 27, 1902, entitled "An act to create a sewerage district to be called Passaic Valley Sewerage District."

The Governor appointed under these acts the following gentlemen to comprise the Passaic Valley Sewerage Commission:
96 Messrs. J. A. Lebkuecher, John Hinchliffe, Francis Child, Peter Houck and William McKenzie.

This commission organized on April 22, 1902, by the selection of Mr. J. A. Lebkuecher as chairman and Mr. John S. Gibson as clerk. On August 18th the commission appointed Mr. Rudolph Hering of New York as its chief engineer. This commission submitted its first annual report to the Legislature on January 23, 1903.

Annual Report of the Passaic Valley District Sewerage Commission for 1902.

This report was submitted on January 23, 1903, and contains besides the general report of the commission the report of its chief engineer Mr. Rudolph Hering and also the draft of the proposed bill which should more thoroughly provide for the carrying out of the sewerage improvements recommended by the commission.

The report of Chief Engineer Hering describes his surveys, examinations and conclusions on the study of two alternate general plans of improvement; namely, first a system of intercepting sewers extending from Paterson to Newark bay by which the sewage of this portion of the valley should be brought to a discharge into the waters of upper New York bay without purification; and second, a system of intercepting sewers, but in place of crude disposal in New York bay the use of one or more purification plants in which the sewage should be treated and the purified discharged into the Passaic river or Newark bay. Mr. Hering's conclusions favor the adoption of the former method. This system which is the one now authorized for construction comprises a main intercepting sewer extending
97 from a point near the Great Falls of the Passaic in the city of Paterson along the right and westerly bank of the Passaic river to a point in the city of Newark where it leaves the river and passes southeasterly through the city across the meadows

to a point on the shore of Newark bay about opposite West Bergen Point, where a main pumping station is to be located. Down to the site of the pumping station this is to be a gravity sewer, but two auxiliary pumping stations are proposed, one at Wallington and one at Lynhurst where sewage from low level sewers on the left bank of the Passaic river to be pumped across the river and into the main intercepting sewer. The pumping station on Newark bay is to force the sewage through two 6 feet diameter steel force mains under Newark bay and up into a gravity sewer which is on the eastern shore of Newark bay in Jersey City at the Morris and Essex canal. This gravity sewer, 13 feet in diameter, leads southeasterly along the canal to a point jutting out into New York bay near Panrapo where the sewer changes to the eight-feet steel pipe laid under New York bay up to a point about three-quarters of a mile northeast of Robbins Reef light in a depth of about 40 feet of water below the mean low tide.

This report also contains the draft of the bill which the commission recommended to the Legislature as being necessary to carry out the improvement proposed. This bill in a somewhat modified form was enacted on April 22, 1903.

The Act of April 22, 1903.

This act modified somewhat from the form recommended by the commission providing for the full powers of the comission and for the procedure to be followed in executing the sewerage improvement under consideration. One of the provisions of this act
98 was that before any work should be undertaken or obligations incurred the Passaic Valley District Sewerage Commission should investigate whether the proposed discharge of sewage into New York bay is likely to pollute the waters of said bay to such an extent or in such a degree as to cause a nuisance to persons or property within the State of New York, and required that the result of such investigation should be presented to the Governor with the opinion of the commission thereon and the reasons for their opinion; thereupon that the same should be considered by the Governor and the Attorney-General and that no work or further proceedings be taken unless the Attorney-General should in writing advise that no cause of action for damages or an injunction would arise in favor of the State of New York or any of its inhabitants by reason of such discharge of sewage into the waters of New York bay.

Special Report of the Passaic Valley District Sewerage Commission Submitted June 8, 1903.

Pursuant to the requirements of the law above quoted the Passaic Valley District Sewerage Commission investigated the subject and reported as their opinion that the discharge of the sewage from the proposed Passaic Valley sewer would not pollute the waters of New York bay to such an extent or to such a degree as to cause a nuisance to persons or property within the State of New York.

The commission submitted as a warrant for its conclusions copies of the written opinions of General Henry M. Roberts, George S. Greene, Jr., E. W. Harrison, O. H. Tittmann, William Barclay Parsons and Allan N. Spooner.

Governor Murphy's Authorization to Proceed.

Governor Murphy having examined the special report submitted by the Passaic Valley District Sewerage Commission referred
99 the same to Attorney-General McCarter for his legal opinion. The Attorney-General having examined the report and having further investigated the case advised the Governor that he found no legal objection to the building of the trunk sewer proposed and that in his opinion there would be no legal objection from the authorities of New York. Thereupon Governor Murphy authorized the sewer commissioners to proceed to the construction of the improvements contemplated.

Constitutionality of Act of April 22, 1903, Maintained by New Jersey Supreme Court.

The acts of 1902-3 were attached by writ of certiorari by the city of Paterson and a citizen of the State, the proceedings bringing up for review the validity of the resolution by the Passaic Valley District Sewerage Commission providing for an issue of $1,000,000 worth of bonds for preliminary work connected with the trunk sewer. The case was argued before three justices, two of whom sustained the constitutionality of the act, handing down their opinion July 23, 1904.

Act of April 22, 1903, Declared Unconstitutional by the New Jersey Court of Errors and Appeals.

An appeal was taken from the decision of the Supreme Court as rendered, and on March 6, 1905, the Court of Errors and Appeals, by a vote of ten to one, reversed the decision of the Supreme Court previously referred to, and declared the act of 1903 unconstitutional, as it is an attempt to delegate an essential element of the power of taxation; because if the taxing power could be deemed to be granted to the commission as a representative of the sewer district, the latter is not a political district of the State, and because if the Passaic Valley Sewerage District were a political district of the State it
100 could not be invested with the power to tax persons and property beyond its own limits.

New York State Law Authorizing an Inquiry.

On May 11, 1903, the Legislature of the State of New York enacted a law (being chapter 539 of the Laws of 1903) entitled "An act to authorize the appointment by the Government of a commission to investigate certain threatened pollution of the waters of New

York bay and making an appropriation for the expenses of such commission." On June 2, Governor Odell appointed as such commission Dr. Daniel Lewis, New York StateCommissioner of Health; Prof. Olin H. Landreth, Consulting Engineer, New York State Department of Health; Dr. George A. Soper, New York State Department of Health Representative at the Ithaca typhoid epidemic; Mr. Louis L. Tribus, Commissioner of Public Works of the Borough of Richmond, Consulting Civil and Hydraulic Engineer; and Dr. Myron S. Falk of New York, Instructor in Engineering in Columbia University.

The New York Commission after organization assigned certain lines of work to its individual members for investigation, which have been completed. The commission has held eight meetings, including two joint meetings with the New Jersey Commission and one public meeting on Staten Island; and has prosecuted several lines of inquiry. It has secured opinions on the legal questions bearing on the situation from the New York State Attorney-General and in March, 1904, submitted to the Governor a short progress report and asked for an extension of time in which to submit the final report, which was granted. It has also, at its meeting Feb. 10, 1905, formulated resolutions outlining the attitude which the commission should adopt toward the Passaic Valley sewerage question.

101 (B.)

Ocean Disposal.

Possible Ultimate Ocean Disposal of all Sewage Wastes from the Metropolitan Districts.

By Commissioner Olin H. Landreth.

The waters of the metropolitan district of New York and adjacent territory, constitute an invaluable heritage to its inhabitants. In their relations to commerce, these waters comprise the chief source of the strength of New York as a commercial metropolis; in their intersection and subdivision of the territory, while in outward appearance they are barriers to intercourse and transportation, in reality they are bonds uniting the several districts by an incomparable net-work of waterways throughout which the distribution of traffic and local transportation is carried on more conveniently, effectively and economically than if the waterways did not exist. In their climatic and sanitary relations they mitigate the heat of summer and offer breathing places and water-parks which no city could afford artificially to provide.

A large proportion of the metropolitan population of New York and adjacent territory passes twice daily over the one or another of the numerous waterways of the district; another considerable portion lives on or near the shores, and still other large numbers frequent the waters for bathing, for pleasure, and as an avenue to numerous nearby water resorts.

It is hardly needful to say that these waters, so important to the interests of the entire metropolitan district, lying both in New York State and in New Jersey, should be protected against impair-
102 ment and injury, and that existing conditions which injuriously affect them should as rapidly as possible be corrected. The most serious menace to these waters lies in their pollution by waters of a great urban district. This pollution has already reached a stage which warrants the closest consideration and the utmost concern. Even the present conditions, unsatisfactory as they are, would have been much worse but for continued past efforts and action looking to the protection of these waters. These restraining efforts have, however, been confined entirely to the matter of the disposal of street sweepings, combustible and noncombustible refuse, and garbage, and while much yet remains to be accomplished along these commendable lines of activity, a decided beneficial result has already been attained, in that a policy of treatment has been adopted, the work organized, the machinery set in motion, and the matter therefore in condition not only to yield beneficial results, but is also readily open to improvement and expansion.

These remedial activities, however, touch only one general class of pollution, namely: the city waste and garbage, which represent, when discharged into the waterways, the chief source of the sedimentary deposits and the visible suspended matter. No steps whatever have been taken, however, toward provision for the proper ultimate disposal of the sewage of this extensive district, if we except a few small municipalities whose aggregate population forms an insignificant part of the entire metropolitan population.

Up to this time the only thought has been how to conduct the sewage by the cheapest route to the nearest waterway, giving no thought whatever to its effect on the waterway and on adjacent waters. While the crude discharge of even moderate
103 amounts of sewage into the waterways is injurious to the waters, the harmful results increase at a more rapid rate than the increase in sewage discharge, and a limit is soon reached beyond which the discharge of sewage produces such obnoxious conditions of the waters as would be condemned by even low standards of quality.

The evidence now available seems to show that this limit is now not far distant and that any considerable increase in the present volume of sewage discharge into the waters of the district will be quite certain to produce decidedly aggravated conditions in those waters, which even present standards of excellence will condemn. Our present standards are, however, too low and the same advancement in public intelligence and taste which demands better public utilities, better sanitation and conditions for living and more exacting requirements in presentable and artstic surroundings, will soon insist on considering the present conditions of our metropolitan waters as repulsive and intolerable.

These two general facts, viz.: that the waters of New York and vicinity are already badly polluted, and that this pollution must of necessity rapidly become worse and soon reach an intolerable limit,

lead us to the problem of the remedy. Two general lines of relief present themselves for alternate consideration.

(1.) Improved sewage disposal for each local district or municipality within or near its own bounds.

(2.) A comprehensive scheme for ocean disposal of the crude sewage of the entire metropolitan district lying both in New York and New Jersey.

On a question of such importance and magnitude even general conclusions should be definitely adopted only after the most
104 able and exhaustive study and investigation, neither of which have the circumstances and conditions attending the appointment and work of this commission rendered possible. Such consideration, however, as it has been possible to give this question seems to point to the second plan, or that of crude discharge out to sea, as the most promising solution of the problem and one which on further investigation will probably be found most feasible and efficient.

The following conclusions appear, therefore, all that may properly be expressed:

(1.) The condition of the waters in and adjacent to the metropolitan district lying both in New York and New Jersey is rapidly approaching a limit in pollution which not only should not be passed, but which already calls for radical relief.

(2.) The two most apparent forms for such relief are:

(*a*) The installation and operation of individual systems of sewage disposal for each district or municipality and the discharge of the purified effluents into the waterways; or,

(*b*) The gathering of the crude sewage of the entire metropolitan district to several centers and the conducting or pumping of the same by one or more outlets or tunnels out to sea at a sufficient distance to insure against its return at flood tide to an extent that would injure the waters of the district.

This plan would probably make desirable the creating of an interstate metropolitan sewerage district created by treaty between the two States of New York and New Jersey and ratified by Congress, and having full administrative powers, with full provision for the questions of legislative, executive and judicial jurisdiction.

105 (3.) The conditions of appointment of this commission have not made it proper or possible to give this matter of relief that exhaustive study and investigation which the importance of the question demands, and therefore no final conclusions or recommendations can be made as between the above two plans of relief or possibly others, beyond a statement that the latter plan of ocean discharge of crude sewage of the entire district appears from the consideration given it to possess the greater advantages.

(4.) This commission is clearly of the opinion that an investigation of the best plan of relief for the waters of New York and vicinity is an urgent necessity and should be undertaken at once, and that pending the completion of such investigation and the inception of the plan of relief, no extensive or considerable changes or extensions should be made in the sewerage of such portions of the metropolitan

district as would be disturbed or sacrificed by the ultimate adoption and installation of a comprehensive scheme of improvement.

106 APPENDIX 5.

Need of the Metropolis District as a Whole and Desirability of Joint State Action.

By Commissioner Daniel Lewis.

The commission, from the very inception of its investigations, has been constantly confronted with the fact that the construction of the proposed Passaic Valley sewer is only one of many serious problems demanding legislative action for the protection of the waters of New York bay against sewage contamination.

The contention of the New Jersey Commission that because the bay is now receiving the raw sewage from 4,000,000 people, therefore an increase from an added population of 1,000,000 or more should be permitted, we believe to be untenable.

The bay is now an immense cesspool, which, like small receptacles of sewage, has a natural limit of capacity, beyond which lies danger to the health and comfort of the contiguous metropolitan district. The residents of New Jersey, who are expected to discharge their waste through the proposed sewer, are equally interested with the inhabitants of New York city in preserving the waters of the bay from further contamination.

It has been suggested, therefore, that a metropolitan sewerage district should be established, to include all sections in both New York State and New Jersey which now, or in future may sewer into the bay and its tributaries. This district, when authorized by joint State and Federal legislation, should be under the direction and control of a permanent interstate commission, with plenary power to control the discharge of all sewers hereafter constructed, as
107 well as the task of evolving a comprehensive plan for ultimately rendering the present chaotic and systemless method of sewage disposal, sanitary and suitable for all future requirements.

There seems to be no possibility of a comprehensive treatment of this great question through the action of various and constantly changing local authorities, acting independently. Manhattan may continue, as at present, to follow no system whatever, simply emptying a new sewer into North or East River at any place where grades permit, even though a recreation pier or a public bath may be already established at the same point. Brooklyn may, and probably will, carry its sewage into the sea, and thus ruin the bathing beaches within its limits, and pollute the great oyster beds therein, and Westchester county for forty miles from the city may contribute a large amount of sewage, while the State of New Jersey with its constantly increasing population, will add to its present outflow from year to year.

The necessity already exists for a central authority to not only direct, but also initiate, these great public works, upon which depend the beauty and healthfulness of the approximately 450 miles of shore within the metropolitan district.

Immediate action should be commenced to secure such an interstate commission, for the existing conditions must steadily approach the point where the public will demand relief.

In this country there is at present but one locality at all analogous to New York in this respect, viz., Boston, where a great metropolitan district empties its sewage into the harbor, but the difference in governing conditions is radical, as but one State is in control, while for New York harbor two great commonwealths would have to join forces.

108 England permitted the pollution of the Thames for centuries, but at last was compelled to purify its waters at a cost far exceedig the expense of preventing such contamination had the demands of competent judges been complied with a hundred years ago.

If New York and New Jersey should now initiate the plan above outlined the mistakes of other great municipalities could be happily avoided.

109 APPENDIX 6.

Legal Opinion.

By Attorney-General John Cunneen.

To the New York Bay Pollution Commission:

I note that you submit for my consideration the following inquiries:

"(1.) What is the status of the waters of New York harbor as to control over pollution by the federal Government and by the two States of New York and New Jersey?

"(2.) Whether the federal government would have jurisdiction over any phase of construction and operation of a large proposed trunk sewer to empty into the waters of New York harbor?

"(3.) What power, if any, has the State of New York to impose conditions upon the State of New Jersey as to constructing the proposed sewer and operating it in future?

"(4.) Whether the New York Bay Pollution Commission is authorized by law to suggest detailed plans for changes in construction of the New Jersey Sewer if same is to discharge into the waters of New York bay, and objection be made to the present plans as formulated by the New Jersey Commission?

"(5.) Whether in the event this commission finds it desirable to recommend for future consideration the establishment of a metropolitan sewerage district, covering parts of the two States of New York and New Jersey, the Legislatures of the two States have authority to establish such a district and appoint a commission having adequate powers of administration?"

(1.) In response to your query No. 1, I beg to call your attention to the provisions of a treaty entered into between the States of New York and New Jersey in the year 1833, and subsequently ratified by the Legislatures of both States and approved by Congress.

The first article of this treaty reads as follows:

110 "Article 1. The boundary line between the two States of New York and New Jersey from a point in the middle of Hudson river opposite the point on the west shore thereof, in the forty-first degree of north latitude, as heretofore ascertained and marked to the main sea, shall be the middle of the said river, of the bay of New York, of the waters between Staten Island and New Jersey, and of Raritan bay to the main sea, except as hereinafter otherwise particularly mentioned."

Among the exceptions is the following, contained in Article III. of said treaty:

"The State of New York shall have and enjoy exclusive jurisdiction of and over all the waters of the bay of New York, and of and over all the waters of Hudson river, lying west of Manhattan Island and to the south of the mouth of Spuyten Duyvil creek, and of and over the lands covered by the said waters to low water mark on the westerly or New Jersey side thereof, subject to the following rights of property and of jurisdiction of the State of New Jersey."

The treaty then proceeds to reserve to the State of New Jersey the exclusive right of property in and to the land under the water lying west of the middle of the bay of New York, and west of the middle of that part of the Hudson river which lies between Manhattan Island and New Jersey, and the exclusive jurisdiction of and over the wharves, docks and improvements made and to be made on the shore of said State, and of and over vessels aground on said shore, or fastened to any such wharf or dock, except that the said vessels shall be subject to the quarantine or health laws and laws in relation to passengers of the State of New York, which now exist or which may hereafter be passed. The right of regulating the fisheries is also reserved exclusively to the State of New Jersey on the westerly side of the middle of said waters.

The case of the People of the State of New York against Central Railroad Company of New Jersey, reported in 42 N. Y., at page 283,

111 reviews at some length the question of the rights of the two States in the waters of the Hudson river south of Spuyten Duyvil creek and west of the center of such river.

This was an action brought by the Attorney-General of the State of New York to abate as nuisances and cause the removal of certain wharves, piers and other erections extending into the harbor and river from the Jersey shore a distance of about a mile. The Court, per Smith, justice, in speaking of the provisions of Article III., which are above quoted, giving the State of New York exclusive jurisdiction over the waters of New York bay, and the Hudson river lying west of Manhattan Island and south of Spuyten Duyvil creek, and of the lands under such waters, says:

"This provision in the treaty most clearly and distinctly gives

and grants to, and vests in the State of New York, full, complete and undoubted control, government and jurisdiction of and over all the waters therein mentioned. Such was the clear intent and purpose of this provision; and so far as it was essential to the proper exercise of such jurisdiction, it gives a control also of and over the land covered by such waters. It doubtless was designed in the clause of said provision in these words: 'Of and over the lands covered by the said waters to low water mark,' to disembarrass the jurisdiction so conferred over the said water, from all pretense of right to interfere therewith arising from the legal maxim, that the owner of the soil owned all above it, cujus est solum, ajus est usque ad coelum.' So that the jurisdiction over the water should be absolute and unquestioned for all practical purposes."

The Court then goes on to point out that the rights over the water so granted to the State of New York were subject to the rights of property and of jurisdiction of the State of New Jersey, and after reviewing the several clauses of the treaty bearing on the jurisdiction of the two States within the waters in question, the following rule was deduced as to the character of the jurisidction of the State of New York:

112 "It was to be a police jurisdiction of and over all vessels, ships, boats or craft of every kind that did or might float upon the surface of said waters, and over all the elements and agents or instruments of commerce, while the same were afloat in or upon the waters of said bay and river for quarantine and health purposes, and to secure the observance of all the rules and regulations for the protection of passengers and property, and all fit governmental control designed to secure the interests of trade and commerce in said port of New York, and preserve thereupon the public peace.

"By this exception, it was designed that vessels afloat upon said bay and river should not escape or evade the quarantine laws, and the laws relating to passengers of New York, by coming to anchor on or near the New Jersey shore, or by becoming attached to the wharves or docks on said shore or adjacent thereto, but in all other particulars they were left subject to the laws of New Jersey."

And again the Court says:

"These articles, I think, properly interpreted, concur in showing that it was the intention of this treaty that both States should retain the absolute control of and over its own soil, and over anything annexed or attached to it, and over every ship, vessel, or other floating craft attached to any wharf or pier, or located in any dock upon its shore, or aground in the waters adjoining its shore, and of and over all persons living or being upon such wharves or vessels, and the property therein; and that each State intended to throw the shield of its State law, and State sovereignty, over all such ships, vessels, persons or property.

"A crime committed upon any vessel fastened to any wharf on the shore, or upon any vessel aground in the waters adjoining the shore of New Jersey, and west of the center of said river or bay, except those offenses specified in the said third article against the

quarantine or health laws, and the laws in relation to passengers of New York, would be, I think, clearly an offense against the peace and dignity of New Jersey, cognizable exclusively in her courts."

It was accordingly held in this case that the Courts of this State had no jurisdiction to restrain the erection or order the removal of the structures complained of.

113 It has, however, been since held, in the case of Ferguson vs. Ross, 126 N. Y., 459, that an action to recover a penalty for an alleged violation of the provisions of chapter 414 of the Laws of 1885, amending chapter 604 of the Laws of 1875, prohibiting the deposit of any material dredged or excavated from a slip, basin or other place in the North or East rivers, or in the bay of New York, within the jurisdiction of the State of New York, might be recovered in an action in the Courts of this State, where such dredgings were deposited in the waters west of the center of the Hudson river and south of Spuyten Duyvil creek, and the right of the State of New York to pass a law imposing such a penalty was upheld.

From a persual of these two cases, it will be seen that the jurisdiction of the State of New York in and to all the waters of the Hudson river and New York bay is primarily a police jurisdiction river and south of Spuyten Duyvil creek, and the right of the State of New Jersey to erect wharves, piers, bulkheads and improvements from its shores into such waters is specifically upheld in the Central Railroad case, from which I have above quoted.

Over and above the rights of the two contiguous States is the right of the federal government in the navigable waters of New York bay and the Hudson river, in so far as the protection of navigation is concerned. (See State of Pennsylvania vs. Wheeling Bridge Company, et al., 13 Howard, 518.)

(2.) In response to the second inquiry, as to "Whether the federal government would have jurisdiction over any phase of construction and operation of a large proposed trunk sewer to empty into the waters of New York harbor," I beg to call your attention to the facts relative to such sewer in the particular case under consideration.

114 In 1902 the Legislature of New Jersey established what was known as the Passaic Valley Sewerage District, which embraced a large number of municipalities and parts of municipalities in the counties of Passaic, Bergen, Hudson and Essex, and at a special session of the Legislature of 1903, an act was passed to relieve from pollution the rivers and streams within such Passaic Valley Sewerage District, and providing for the raising, collecting and expenditure of the necessary moneys.

The plans of the commission appointed under these acts provide for the emptying of the sewage from the district in question, which is estimated to contain nearly one million and five hundred thousand inhabitants, into the waters of New York bay near Bedloes Island on the New Jersey side of the State line, as defined in Article III, of the treaty hereinbefore quoted from.

No facts have been submitted as to whether or not the construction of the proposed sewer and its operation would, as matter of

fact, interfere with the navigation of the Hudson river and New York bay. If there is any such interference, I am of the opinion that the federal government might and would interpose and assert its rights to free such river or harbor from such obstruction or interference with navigation.

As to the jurisdiction of the federal government in the matter, it would seem to me that under the authority of the State of Missouri vs. State of Illinois, and the Sanitary District of Chicago, the Supreme Court of the United States would have original jurisdiction in any proceeding which might be instituted by the State of New York to restrain the construction or operation of the proposed sewer.

The case above mentioned arose in regard to the construction and operation of the so-called Chicago Drainage canal, whereby
115 the sewage from the city of Chicago was, through the intermediate channels of the Drainage canal and the Illinois river, emptied into the Mississippi river, which at that point runs between the States of Illinois and Missouri.

The State of Missouri sought in the Supreme Court of the United States to restrain the emptying of such sewage into the Mississippi river. The bill in the action was demurred to, but the Court sustained the right of the State of Missouri to maintain its proceeding. The Court said:

"An inspection of the bill discloses that the nature of the inquiry complained of is such that an adequate remedy can only be found in this Court at the suit of the State of Missouri. It is true that no question of boundary is involved, nor of direct property rights belonging to the complainant State. But it must be surely conceded that, if the health and comfort of the inhabitants of a State are threatened, the State is the proper party to represent and defend them. If Missouri were an independent and sovereign State all must admit that she could seek a remedy by negotiation, and, that failing, by force. Diplomatic powers and the right to make war having been surrendered to the general government, it was to be expected that upon the latter would be devolved the duty of providing a remedy, and that remedy, we think, is found in the constitutional provisions we are considering.

"The allegations of the bill plainly present such a case. The health and comfort of the large communities inhabiting those parts of the State situated on the Mississippi river are not alone concerned, but contagious and typhoidal diseases introduced in the river communities may spread themselves throughout the territory of the State. Moreover, substantial impairment and prosperity of the towns and cities of the State situated on the Mississippi river, including its commercial metropolis, would injuriously affect the entire State."

The above reason would apply with equal force to the case under consideration. The sewage from territory inhabited by a million
116 and a half of people, cast into the waters of New York harbor, in addition to the sewage already emptied into those waters, might easily create a condition which would injure the health

of the great city of New York, which is the metropolis not only of the State, but of the country.

It is, therefore, quite clear to my mind that should such a condition arise, the State of New York would be authorized to begin proceedings in the Supreme Court of the United States to compel the State of New Jersey and the Passaic Valley Sewerage District to refrain from polluting the waters of New York harbor with this great mass of sewage.

(3.) In response to your third inquiry, I beg to inform you that while the State of New York can, of course, enter into any negotiations it sees fit with the State of New Jersey, yet it cannot impose and enforce any conditions in reference to the construction and operation of such sewer, upon the Passaic Valley Sewerage District or the State of New Jersey, which would be enforcible in any other way than by a proceeding in the United States Supreme Court, to restrain the use and operation of such sewer. In other words, while under the authority of Ferguson vs. Ross, above cited, the State of New York might pass a law prescribing a penalty for dumping sewage in the waters of New York harbor or the Hudson river as far west as low water mark on the New Jersey shore, yet I am of the opinion that such a penalty could not be enforced or collected as against the State of New Jersey or the Passaic Valley Sewerage District, in the Courts of this State, and that, therefore, the proper forum from which to seek redress would be the United States Supreme Court.

(4.) In response to your fourth inquiry, I beg to call your attention to the statute creating the investigating commission of this State. Section two thereof provides as follows:

117 "Such commission shall confer with the authorities of the State of New Jersey, take the testimony of witnesses, if necessary, and otherwise make such investigations as it may deem advisable, to determine the character of such threatened pollution, if any, and the means necessary to effectually prevent the same, in order to protect the health of the people of this State."

In view of the fact that the State of New Jersey would in no way be bound to act upon any specific recommendations or suggestions of detailed plans for changes of the construction of the sewer in question, I see no reason why your commission might not submit such suggestions and recommendations, if it saw fit, the same as it might submit the same at any oral conference had under the provisions of the sections above quoted with the authorities of the State of New Jersey.

(5.) As to the fifth and last inquiry, I am of the opinion that the States of New York and New Jersey may, if they see fit, construct a metropolitan sewerage district, covering parts of the territory of the two States, and giving jurisdiction thereover to the Courts of one of the other of said two States, as to all matters pertaining to the proper sewerage of said district. Such concurrent acts of the States of New York and New Jersey should, however, in my judgment, be approved and ratified by an act of Congress, for the reasons hereinbefore set forth, namely, that the federal government

has supreme control over the navigable waters of the Hudson river and New York bay, and its approval should therefore be had to the joint action of the contiguous States.

As to the power of the Attorney-General to proceed against the State of New Jersey and the Passaic Valley Sewerage District to restrain the construction or operation of the proposed sewer, I am of the opinion that section 52 of the Executive law, which
118 gives to the Attorney-General power to "prosecute and defend all actions and proceedings in which the State is interested," is broad enough in its terms to include the authority to begin such restraining action. In support of this theory, it will be noted the right of the Attorney-General to begin a similar action does not seem to have been questioned in the case of the People vs. The Central Railroad of New Jersey, hereinbefore quoted from, and the case of Missouri vs. Illinois specifically holds that the pollution of a navigable stream is a matter in which the State is interested, and therefore a proper one for its legal representatives to act in behalf of the State.

119 APPENDIX 7.

New York Law—Authorizing Appointment of Commission.

General—All Counties.

Laws of New York—By Authority.

(Every law, unless a different time shall be prescribed therein, shall not take effect until the twentieth day after it shall become a law. Section 43, article II, chapter 8, General Laws.

Chapter 539.

An Act to authorize the appointment by the Governor of a commission to investigate certain threatened pollution of the waters of New York bay, and making an appropriation for the expenses of such commission.

Became a law, May 11, 1903, with the approval of the Governor. Passed, three-fifths being present.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. The Governor is hereby authorized to appoint a commission, consisting of five members, to investigate the alleged contemplated construction of a sewer or sewers in the State of New Jersey and the discharge therefrom of sewage into the waters of New York bay. The members of such commission shall receive no compensation for their services, but shall be entitled to their actual necessary traveling and other expenses incurred in the performance of

their duties. Such commission shall organize by the selection of one of its members as chairman and another as secretary.

120 §2. Such commission shall confer with the authorities of the State of New Jersey, take the testimony of witnesses, if necessary, and otherwise make such investigations as it may deem advisible to determine the character of such threatened pollution, if any, and the means necessary to effectually prevent the same, in order to protect the health of the people of this State.

§3. Each member of such commission shall have the power to administer oaths, and the commission shall have power to subpœna witnesses and take testimony, and in addition shall have all the powers of legislative committees as provided by article three of the Legislative Law. On or before February first, nineteen hundred and four, the commission shall report to the Governor the result of its investigation, together with such recommendations as to needed legislation or other action on the part of the State to prevent the pollution of the waters of New York bay from the causes specified in this act, as it may deem advisable.

§4. The sum of two thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of any moneys in the treasury, not otherwise appropriated, for the purposes of this act, to be paid by the treasurer on the warrant of the comptroller, on the order of the chairman of such commission.

§5. This act shall take effect immediately.

STATE OF NEW YORK,
Office of the Secretary of State, ss:

I have compared the preceding with the original law on file in this office, and do hereby certify that the same is a correct transcript therefrom and of the whole of said original law.

JOHN F. O'BRIEN,
Secretary of State.

121 APPENDIX 8.

An Act to Provide for the Appointment of a Metropolitan Sewerage Commission and Making an Appropriation Therefor.

The people of the State of New York, represented in Senate and Assembly, do enact as follows:

Section 1. The Governor is hereby authorized to appoint within thirty days after the passage of this act five citizens of the State, two at least of whom shall be residents of the city of New York, who together with the State Engineer and Surveyor, the State Attorney-General and the Mayor of the city of New York shall constitute a temporary commission to be known as the New York Metropolitan Sewerage Commission. One at least of the five citizen members should be a lawyer and two at least should be civil engineers.

§2. The duties of this commission shall be to continue the work of the New York Bay Pollution Commission established by chap-

ter five hundred and thirty-nine of the Laws of nineteen hundred and three and to extend the work of this commission so as to include the following duties:

(1.) To make further investigations into the present and probable future condition of the purity and pollution of the waters of New York bay, and of the rivers and other bodies of water tributary thereto and adjacent to the several boroughs of New York city and its neighboring districts.

(2.) To consider and investigate the present conditions and the future needs for sewerage and sewage disposal in New York
122 city and in the adjoining municipalities and neighboring districts.

(3.) To cooperate with any duly authorized body or commission having similar authority from the State of New Jersey, in the joint consideration of the most effective, efficient and feasible means of permanently improving and protecting the purity of the waters of New York bay and of the rivers and other bodies of water tributary and adjacent thereto, making, in addition to other inquiries, examinations, investigations and surveys to determine the best plan for the final disposal of the sewage of the entire metropolitan district lying in both States, either by discharging or pumping the same through large outlet sewers or tunnels out to sea, or by other means; and also giving particular consideration to the best system of administrative control for the inception, execution and operation of such plans for ultimate sewage disposal by a separate and distinct sewerage district and a permanent commission in each State, or by one interstate metropolitan sewerage district and commission to be established by an agreement between the two States; if necessary, to be ratified by Congress, or by other means.

(4.) To submit to the Legislature in writing on or before February first, nineteen hundred and eight, a full and complete report of its investigations, surveys and estimates of cost of the several plans deemed worthy of especial consideration. Also to submit such definite conclusions and recommendations as may have been reached conjointly by the Metropolitan Sewerage Commission herein established acting in conjunction with any similar body appointed by the State of New Jersey, relating to the most effective, efficient and feasible means or plan of permanently improving and protecting the purity of the waters of New York bay and of the rivers and other
123 bodies of water tributary and adjacent thereto, as well as a definite scheme for the administration of the inception, execution, permanent operation and government of such means or plan of improvement and protection.

§3. The members of the New York Metropolitan Sewerage Commission herein provided for, shall before entering upon the discharge of their duties take and subscribe the constitutional oath of office and file the same with the Secretary of State. They shall within twenty days after appointment, and at the call of the State Engineer, meet at the office of the latter in Albany and shall organize by the selection of one of the members to be chairman of the commission and another to be its secretary.

The commission may engage such engineering, legal, and other expert services and advice, and such clerical, stenographic and other assistance as it may deem necessary for the prosecution of its duties.

§4. Each member of the commission shall have the power to administer oaths, and the commission shall have the power to subpœna witnesses and take testimony, and in addition shall have all the powers of legislative committees as provided by article three of the Legislative Law. The members of the commission and all persons duly authorized by the commission shall have the right of entry and passage to any place or property for the purpose of making surveys or examinations.

§5. The commission shall terminate on February 1, 1908, and all maps, results or surveys and examinations, estimates and other papers and matter acquired by the commission shall be properly indexed and labelled and turned over to the State Engineer and Surveyor.

124 §6. The members of the commission shall receive no salary but shall be paid their reasonable and necessary expenses actually incurred in the prosecution of their duties, and the five citizen members shall be each paid a just and reasonable per diem compensation, to be determined by the Governor, for the time actually and necessarily employed on the work of the commission.

§7. The sum of fifteen thousand dollars, or so much thereof as may be necessary, is hereby appropriated out of any money in the treasury not otherwise appropriated, for the purposes of this act, to be paid by the State Treasurer on the warrant of the Comptroller on the order of the chairman of the commission.

§8. The Secretary of State is hereby authorized and requested to communicate with the Governor of the State of New Jersey, transmitting with the Governor of the State of New Jersey, transmitting a copy of this act and to extend through him an invitation to the State of New Jersey to cooperate with the State of New York in the carrying out of the purposes to be attained by this act and to appoint a commission to represent the State of New Jersey and unite with the New York commission authorized by this act in the investigations, surveys, conclusions and recommendations herein provided, it being desired that, if possible, the two commissions may reach similar conclusions and agree on a common plan for the accomplishment of the purposes to be attained by this act, and that they may submit identical or similar reports and recommendations to their respective legislatures.

§9. This act shall take effect immediately.

125 APPENDIX 9.

List of Meetings Held by the Commission and Special Features Considered Thereat.

June 30, 1903—All members of the commission present (five).
Meeting held on board New York State Board of Health Steamer "Governor R. P. Flower."
Inspection of New York harbor; organization of commission; Dr. Daniel Lewis, chairman; Louis L. Tribus, secretary. Assignment of subjects to members of commission for special individual investigation.
November 30, 1903—Four members of the commission present.
Meeting held in New York city.
Consideration of important details of New Jersey project; authorization given for special trips of investigation of sewage disposal systems.
December 22, 1903—All members of the commission present.
Meeting held in office of the President of the Borough of Richmond, New Brighton, S. I.
Public hearing and testimony, taken under oath, of pilots, etc., as to tidal currents, and discussion of shellfish industries and location of beds.
January 22, 1904—All members of the commission present.
Joint session of New York Commission and Passaic Valley District Sewerage Commission.
126 Meeting held in New York city.
General and free discussion of New Jersey project.
February 5, 1904—All members of the commission present.
Meeting held in office of the State Commissioner of Health at Albany.
Discussion of proposed report and topics to be considered therein. Consultation with Deputy Attorney-General upon legal questions involved in report.
February 12, 1904—All members of the commission present.
Joint session of New York Commission and Passaic Valley District Sewerage Commission.
Meeting held in office of the latter in Newark, N. J.
General discussion of details of New Jersey project and hearing of arguments of the engineers of the Passaic Valley Commission in answer to written questions previously presented by the New York Commission.
February 10, 1905—All members of the commission present.
Meeting held in New York city.
Discussion of individual reports presented by members of the commission upon their special investigations to date. Selection of features for final report, and general form of recommendations to be incorporated in a legislative bill.
March 10, 1905—All members of the commission present.
Meeting held in New York city.

Discussion of draft of final report as prepared by the Secretary.

The Secretary authorized to complete same with amendments
127 as suggested, and with the chairman to present it personally to the Governor at the earliest feasible date. To have report printed as soon as possible thereafter, for general distribution.

128 APPENDIX 10.

Financial Statement.

Appropriation				$2,000 00
Disbursements:				
1903.				
Oct. 15.	Evening Union Co., stationery and printing.	$12 65		
Dec. 10.	Louis L. Tribus, Secretary, traveling, postage and typewriting.	41 05		
March 14.	Louis L. Tribus, Secretary, traveling, postage and typewriting.	67 71		
	John P. Martin traveling and stenographic service	356 37		
May 26.	Daniel Lewis, traveling expense	48 75		
July 26.	Louis L. Tribus, Secretary draft of map and typewriting	90 16		
	Olin H. Landreth, traveling and typewriting	123 54		
			$740 23	
Accounts due:				
1905.				
	George A. Soper, traveling and analyses	$484 40		
129	Myron S. Falk, traveling and typewriting	13 94		
	Olin H. Landreth, traveling and typewriting	36 18		
	Louis L. Tribus, Secretary, traveling, map exhibit, report binders and typewriting	246 60		
			781 12	
				$1,521 35
Balance towards final petty expenses and publication of report				$478 65

130 APPENDIX 11.

Names of Those Rendering Special Assistance to Commission.

Bauer, Jacob L., Civil Engineer, Elizabeth, N. J.
Bender Hygienic Laboratory, Albany, N. Y.
Bridgman, Edw. C., Map Publisher, New York.
Brown, Wm. M., Chief Engineer Metropolitan Sewerage Commission, Boston, Mass.
Cantor, Jacob A., President Borough of Manhattan, New York.
Cassidy, Joseph, President Borough of Queens, New York.
Church, Sanford T., Deputy Attorney-General, Albany, N. Y.
Cooper, Sam'l L., Commissioner Public Works, Yonkers, N. Y.
Cromwell, George, President Borough of Richmond, New York.
Cunneen, John, Attorney-General, Albany, N. Y.
Fetherston, John T., Civil Engineer, New Brighton, N. Y.
Forest, Fish and Game Commission, Albany, N. Y.
Freeman, L. W., Civil Engineer, Mariners Harbor, N. Y.
Glorieux, Wm. L., President South Orange, etc., Joint Sewer Commission, Irvington, N. J.
Grabkowitz, J. M., Draughtsman, New Brighton, N. Y.
Grunenthal, A. F., Draughtsman, New Brighton, N. Y.
Haffen, Louis F., President Borough of The Bronx, New York.
Harrison, E. W., Civil Engineer, Jersey City, N. J.
Hommann, C. C., Civil Engineer, Perth Amboy, N. J.
Housman, Jacob, Oyster Dealer, Mariners Harbor, N. Y.
Jackson, Daniel D., Chemist, Brooklyn, N. Y.
Kohler, Capt. C. H., Superintendent Staten Island Rapid Transit Ferry Company, New Brighton, N. Y.
131 Lennon, John J., Stenographer, New Brighton, N. Y.
Livingston, George, Commissioner of Public Works, Borough of Manhattan, New York.
Loomis, Horace, Chief Engineer Sewers, Borough of Manhattan, New York.
Luster, W. H., Jr., Civil Engineer, Elizabeth, N. J.
Mackenzie, Gen. A., Acting Chief of Engineers, U. S. Army, Washington, D. C.
Marshall, Chas. A., Secretary to the Commissioner of Public Works, Borough of Richmond, New York.
Marshall, Lieut.-Col. W. L., U. S. Engineer Corps, New York.
Martin, John P., Court Stenographer, New York.
Massa, Chas. G., Civil Engineer, Fort Lee, N. J.
Muirhead, Chas. H., Mayor, South Orange, N. J.
McCann, Thos. H., Civil Engineer, Hoboken, N. J.
Musgrave, Francis W., Stenographer, New Brighton, N. Y.
Oxholm, Theodor S., Civil Engineer, West New Brighton, N. Y.
Pearce, Dr. R. M., Director of Bender Laboratory, Albany, N. Y.
Potter, Alexander, Civil Engineer, New York.
Raymond, Lieut.-Col. C. W., U. S. Engineer Corps, New York.
Redfield, Wm. C., Commissioner of Public Works, Borough of Brooklyn, New York.

Ryan, P. J., Mayor, Elizabeth, N. J.

Seehusen, Ernest H., Superintendent Bureau of Sewers, Borough of Richmond, New York.

Silva, J. J., Quarter-master Staten Island Rapid Transit Ferry Company, New Brighton, N. Y.

Stickney, Col. Amos, U. S. Engineer Corps, New York.

Suter, Col. Chas. R., U. S. Engineer Corps, New York.

132 Swanstrom, J. Edward, President Borough of Brooklyn, New York.

Thatcher, John, Superintendent Bureau of Sewers, Borough of Brooklyn, New York.

United States Census Bureau, Washington, D. C.

United States Commission of Fish and Fisheries, Washington, D. C.

United States Steamboat Inspection Service, New York.

Van Pelt, Capt. F. P., Superintendent New York, New Jersey and Sandy Hook Pilots' Association, New York.

Whittemore, Walter F., Civil Engineer, Hoboken, N. J.

Wyeth, Charles, New York State Surveyor of Oyster Lands, New York.

133 *Index.*

	Page.
Act of New York authorizing New York Bay Pollution Commission 7,	100, 119
Act of New Jersey, March 24, 1897, Pollution Upper Passaic River	90
Act of New Jersey, April 22, 1903, Powers of Passaic Valley District Sewerage Commission	97
Bacillus coli communis, found in New York harbor waters	19, 49
Bacterial evidence in shell fish	18, 56
Bacterial evidence in water	19, 48
Boston, sewage in harbor 20,	82, 107
Chemical evidences of pollution	19, 58
Clam and oyster industry	18, 74
Court of Errors and Appeals, New Jersey act unconstitutional	25, 99
Cunneen, John, Attorney-General, opinion on questions submitted	28, 109
Currents, tidal	10, 39
Deer Island, Boston harbor, sewer outlet	82
Digestive power of salt waters for sewage	70
Disbursements of commission	128
Ebb tide, path of	12, 33
Falk, Myron S., appointment as commissioner	100
Report on tidal conditions	33
Federal control over New York harbor waters	28, 113
Flood tide, path of	13, 34
Fresh water flow from Hudson River	37
Fresh and salt waters, relative percentages	61

	Page.
Hearing, meeting of December 22, 1903	125
Higgins, Governor Frank Wayland, report of New York Bay Pollution Commission, made to	5
Industries affected by pollution in harbor waters	18, 20
Joint State action, discussion of needs for	27, 106
Landreth, Olin H., appointment as commissioner	100
Report on legislative history of New Jersey project	89
Report on ocean disposal	101
Laws, New Jersey, affecting pollution, Passaic River	21, 89
State Sewerage Commission	22, 91
Powers of Passaic Valley District Commission	22, 97
134 Laws, New York, appointment of New York Bay Pollution Commission	7, 100
Chap. 539, Laws 1903	119
Legal questions for opinion of New York State Attorney-General	28, 109
Legislative history of New Jersey sewerage project	21, 89
Bills proposed by New York Bay Pollution Commission 1905	121
Committee, New Jersey, 1898	21, 90
Lewis, Daniel, appointment as commissioner	100
Report on metropolitan district and need for joint State action	106
Map, subjects in report noted thereon	9
Minutes, meetings of New York Bay Pollution Commission	125
Moon Island, Boston Harbor, sewer outlet	20, 82
Names of those assisting the commission	130
New Jersey, Acts of legislature, pollution of Passaic River	21, 89
Acts of legislature appointing State Sewerage Commission	22, 91
Acts of legislature, powers of Passaic Valley Commission	22, 95
Appointment of Passaic Valley District Sewerage Commission	23, 95
Court of Errors and Appeals declaring act unconstitutional, 1905	25, 99
Governor's authorization to commence Passaic sewer	24, 98
Report of Passaic Valley Sewerage Commission, February 26, 1897	21, 90
Report of Passaic Valley District Sewerage Commission for 1902	23, 96
Report of Passaic Valley District Sewerage Commission (special, June 8, 1903)	24, 98
Report of State Sewerage Commission for 1899	92
Report of State Sewerage Commission for 1900	93
Report of State Sewerage Commission for 1901	94
Report of State Sewerage Commission for 1902	95
Supreme Court declaring Sewerage Act constitutional, 1904	24, 99

	Page.
New York Bay Pollution Commission, appropriation for expenses	120, 128
Authority to conduct hearings	120
Authority for conferences	120
Authority for expenditures	119
Law of appointment (Chap. 539, 1903)	119
Legal status, interstate	28, 109
List of special individual reports	8
Ocean disposal of sewage	25, 101
Odell, Governor Benj. B., Jr., appointing New York Bay Pollution Commission	6, 100
Oyster and clam industry	18, 74
Passaic Valley District Sewerage Commission, appointment	22, 95
Report for 1902	23, 96
Special engineering report, June 8, 1903	24, 98
135 Passaic Valley Sewerage Commission, appointment.	21, 90
Report February 26, 1897	21, 89
Questions for legal advice from Attorney-General (N. Y.)	28, 109
Salt and fresh waters, percentages	61
Sanitary control over waters by New York State	28, 113
Sewage in New York harbor	15, 12
Sewers in metropolitan district	13, 44
Shad fishery in New York harbor	18, 73
Shell fisheries in New York harbor	18, 74
Soper, Geo. A., appointment as commissioner	100
Report on analyses of waters and shell fish	47
Report on industries affected by pollution	73
Tidal flow in New York harbor	10, 35
Storage in New York harbor	12, 36
Waters as purifying agents	60
Tides, time of	38
Treaty, New York and New Jersey in 1833	28, 109
Transportation in New York harbor	20, 78
Tribus, Louis L., appointment as commissioner	100
Report on present sewage pollution in New York harbor	42
Underrun of salt water	11, 40, 68

136 University of the State of New York.

STATE OF NEW YORK,
Office of the Commissioner of Education, ss:

I have compared the annexed copy of Senate Document No. 39, for the year 1905 with the copy of the same deposited in the New York State Library, and do hereby certify that the same is a correct copy thereof and of the whole thereof.

[Seal State of New York, Education Department.]

PLINY T. SEXTON,
Vice Chancellor of the University, Acting
Commissioner of Education.

1 EXHIBIT No. 3.

James D. Maher, Commissioner.

STATE OF NEW YORK:

Report of the New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, April 30, 1906.

Commissioners: Daniel Lewis, Chairman, Olin H. Landreth, Myron S. Falk, George A. Soper, Louis L. Tribus, Secretary.

Transmitted to the Legislature May 3, 1906.

(Here insert map marked page 1 Exhibit No. 3.)

2 STATE OF NEW YORK:

Report of the New York Bay Pollution Commission to Hon. Frank Wayland Higgins, Governor, April 30, 1906.

Commissioners: Daniel Lewis, Chairman; Olin H. Landreth, Myron S. Falk, George A. Soper; Louis L. Tribus, Secretary.

Transmitted to the Legislature May 3, 1906.

3 STATE OF NEW YORK:

No. 76.

In Assembly, May 3, 1906.

Second and Final Report of the New York Bay Pollution Commission to Frank Wayland Higgins, Governor of the State.

STATE OF NEW YORK:

EXECUTIVE CHAMBER,
ALBANY, May 3, 1906.

To the Legislature:

I herewith submit the report of the New York Bay Pollution Commission.

FRANK W. HIGGINS.

NEW YORK, April 30, 1906.

Hon. Frank Wayland Higgins, Governor, State of New York, Albany, N. Y.:

SIR: Under date March 31, 1905, the New York Bay Pollution Commission presented to you its report of investigations
4 carried on during the two preceding years concerning the condition of the waters of New York Bay and vicinity, and making certain recommendations. As the presentation of our report was unavoidably delayed until nearly the close of the legislative session; acting on your suggestion, the Legislature continued the life of the commission for another year, and made a small appropriation for its expenses, rather than at that late date taking up the question of authorizing the appointment of a new commission with broader powers, and an appropriation sufficient to carry on much further the work begun. With the small sum of money at its command, the commission has been unable to do other than continue in a small way some of the examinations which it felt to be most essential, namely, bacteriological and sanitary examinations of the waters and shores of the harbor. The accompanying report of the sub-committee (Appendix) confirms quite strikingly the conclusions arrived at by the earlier investigations, as reported upon last year, demon-

strating still more clearly the need for full study and the earliest possible consideration of the whole question of preventing the further pollution of the waters in question and the ultimate doing away with even the present causes of contamination.

Certain objections had been made to the form of the bill which the commission suggested a year ago, so that a new measure has been under consideration for this year's action, similar in its general purport but differing in some special details.

The technical journals and the daily press of New York city have given much publicity to the matters reported upon, and commend very fully the work already done and that proposed for the future. The Chamber of Commerce of the State of New York, the Merchants' Association of New York, the Board of Trade
7 & 6 and Transportation, the Maritime Association of the Port of New York, the New York Produce Exchange, the City Club, the American Scenic and Historic Preservation Society, the Municipal Engineers of New York City, and other representative bodies have given evidences of being very much alive to the necessity of the case.

The status of the New Jersey legislation remains unchanged since our last report, except that a special session of the New Jersey Legislature is likely to be called in September to consider the subject very fully.

There has been so great an interest taken in this matter, that the commission would ask for the printing of an additional edition of its former report, the present one having long since become practically exhausted. It would seem desirable to have such edition made an appendix of this report, so that all those interested in the subject may readily compare this year's results with those formerly presented.

Respectfully submitted,

NEW YORK BAY POLLUTION COMMISSION.
DANIEL LEWIS *Chairman*.
OLIN H. LANDRETH.
GEORGE A. SOPER.
MYRON S. FALK.
LOUIS L. TRIBUS, *Secretary*.

Report on the Sanitary Conditions of New York Bay as Shown by Chemical and Bacteriological Analyses of the Waters and Inspections of the Shores.

By George A. Soper, Special Committee, April 30, 1906.

9 The Sanitary Condition of New York Bay as Shown by Chemical and Bacteriological Analyses of the Waters and Inspections of the Shores.

By Commissioner George A. Soper.

The sanitary examinations of the waters of New York Bay and vicinity recorded in the first report of the New York Bay Pollution Commission, made May 1, 1905, have since been continued and extended. The conclusions hitherto reached have been, for the most part, fully confirmed by the studies of the last year.

Before undertaking to consider the most recent work of the commission, the more essential of the conclusions already reached may be repeated:

(1.) The effects of the present pollution of New York Bay, although not great, are nevertheless measurable.

(2.) A careful study of the water in the bay and rivers about New York shows that the sewage of New York City is not promptly flushed out to sea, except during freshets in the Hudson.

(3.) It is probable that most of the sewage which enters the bay is disposed of in the bay by animals and plants, chiefly the bacteria which live in this water.

(4.) The drainage which now enters the bay does so in the most favorable manner possible for diffusion; that is, from a large number of outlets situated along an extensive shore line.

10 (5.) How much sewage and other organic matter can be emptied into the bay without killing those forms of life which now destroy the sewage and so creating a general nuisance, it is impossible to say. This is a matter of great importance, but its proper study requires analyses and experiments which have been beyond the reach of this commission.

(6.) Compared with fresh water streams or the ocean, New York Bay is not a favorable place for the inoffensive disposal of sewage.

(7.) Should the bay become overloaded with sewage, the odors which would arise from it would be particularly offensive.

(8.) The total amount of solid matter which now enters the bay with house and street sewage every twenty-four hours is approximately equivalent to 1,047 tons of dry sludge. About one-half of this is organic matter.

(9.) Long before a general nuisance is produced, local nuisances will occur, as may be seen at present where sewage and drainage

COPY BOUND

from industrial works empty into still, or comparatively still water in this vicinity.

(10.) The oyster beds in New York Bay are almost exclusively located on the southeast side of Staten Island and Gravesend Bay, beyond the Narrows.

(11.) Most of the oyster and clam beds are now free from dangerous pollution, although there are some on the Staten Island shore near the Narrows and the Kill von Kull, and some in Gravesend Bay, which are nearer sewer outfalls than is proper.

(12.) The increasing amount of pollution to which the waters of New York Bay are subject makes it seem only a question of time when oyster culture will be driven from this locality; but
11 with wise and careful protection, a large part of the present oyster grounds can be kept safe for some years to come.

(13.) The almost universal custom in this vicinity of "drinking," that is, bleaching and bloating oysters in polluted streams of fresh water, places all shellfish under suspicion of being contaminated.

(14.) The pollution of the bay has had no visible effect upon the number of fish caught in the vicinity of New York, although petroleum and other industrial wastes appear to have occasionally affected the flavor, and consequently the value, of small catches of shad.

(15.) The natural increase in population of New York and vicinity will, by 1930, probably increase the present amount of pollution about 65 per cent.

The principal points of information sought in the recent work of the commission have been—(1) To determine whether the waters of New York Bay were comparatively uniform in quality at all depths, or whether a perfect mixture of the salt water, fresh water and sewage which entered it did not occur; (2) Whether the waters of the East River, Harlem River and Hudson River bore positive evidence of pollution; (3) Whether the supply of oxygen was always sufficient for the oxidation of the organic matter by the bacteria.

The analyses have been confined to chemical and bacteriological determinations uniform in character with those recorded in the first report of the commission. The methods of analysis and the ways of expressing the results have been the same. There have been one hundred and fifteen chemical analyses and the same
12 number of bacteriological examinations. As a rule, samples for chemical and bacteriological analyses were collected simultaneously. The total number of analyses was very small, considering the size of the problem to be studied.

The great extent of the harbor and its tributaries and the multiplicity of the conditions of pollution and purification which called for investigation needed far more extensive analytical studies than the slender means of the commission permitted. The analytic work done thus far should be regarded only as an indication of the great value and meaning which would attach to similar work if carried out on a large scale.

CLOSE IN CENTER

It is hoped, if further studies are to be made of the conditions of these waters, that opportunities will be afforded for keeping the harbor and adjacent waters under adequate observation for at least one full year. Facilities should be provided for the collection and analysis of several thousand samples.

The numbers of bacteria found were, in most cases, smaller than would be expected from the results of analyses published by the commission in its first report. The numbers would have been larger had the observations been made in the summer season, for cold exercises a restraining action on the growth and multiplication of bacteria.

A sanitary inspection of the shores of the bay was made in order to discover, if possible, whether any visble evidence of pollution by sewage, garbage or other refuse existed there. This inspection yielded unexpectedly interesting and instructive results.

13 A—Results of Bacteriological Analyses.

Analyses were made to determine the numbers of bacteria in the waters and, to some extent, their kind. The principal kind looked for was B. coli, an invariable accompaniment of sewage. The examinations for B. coli were made by the "presumptive test," already described in the first report of the New York Bay Pollution Commission, and checked by means of a special method which has come into regular use at the Mount Prospect laboratory, Brooklyn, N. Y. This method has not yet been published and cannot, consequently, be fully described here. It will be known as the "bile lactose method" and was devised by Mr. D. D. Jackson into whose hands the actual work of the bacteriological and chemical analyses for the commission has been intrusted. ,

1. Bacteria at Different Depths in Upper New York Bay.

Samples of water were taken for analysis at different depths in upper New York Bay to determine whether there was an appreciable difference in the bacterial condition of the water at the surface and at different points toward the bottom. The results are given in tables 1 and 2.

Table 1. Results of bacterial analyses of water taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 28, 1906, between 10:00 a. m. and 3:30 p. m. At Governors Island the tide was high at 10:40 a. m. and low at 5:12 p. m. The wind was north to northwest, with a minimum velocity of 4 miles per hour between noon and 1:00 p. m. and 13 miles per hour between 3:00 and 4:00 p. m.

COPY BOUND C

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		a. m.					
51	Narrows opposite Fort Hamilton.	10:00	5	1,200	+	+	+
52	Narrows opposite Fort Hamilton.	10:10	40	270	+	+	+
53	Narrows opposite Fort Hamilton.	10:15	80	90	+	+	+
54	¾ mile north Robbins Reef.....	10:53	5	1,730	+	+	+
55	¾ mile north Robbins Reef.....	11:15	40	400	+	0	+
56	¾ mile north Robbins Reef.....	10:58	80	260	0	0	0
57	Off Battery and Governor's Island, mid stream.....	*p. m.* 2:40	at surface	3,330	0	+	+
58	Off Battery and Governor's Island, mid stream.....	2:30	5	1,540	+	+	+
59	Off Battery and Governor's Island, mid stream.....	2:35	20	1,180	+	+	+
60	Off Battery and Governor's Island, mid stream.....	2:22	40	730	+	+	+
61	Off Battery and Governor's Island, mid stream.....	2:38	60	560	0	0	0
62	Off Battery and Governor's Island, mid stream.....	2:15	80	460	+	+	+
63	¾ mile north Robbins Reef.....	3:05	5	2,160	+	+	+
64	¾ mile north Robbins Reef.....	3:57	40	380	+	+	+
65	¾ mile north Robbins Reef.....	2:45	80	260	+	+	+
66	Narrows	3:21	5	1,090	+	+	+
67	Narrows	3:24	40	810	0	+	+
68	Narrows	3:30	80	970	+	+	+

Table 2. Results of bacterial analyses of water taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 30, 1906, between 11:00 a. m. and 3:40 p. m. High water occurred at Governor's Island at 12:05 p. m. The wind was south and varied from 10 to 15 miles per hour.

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		a. m.					
69	Narrows opposite Fort Hamilton.	11:12	5	220	+	+	+
70	Narrows opposite Fort Hamilton.	11:05	40	390	0	+	+
71	Narrows opposite Fort Hamilton.	11:00	80	350	+	+	+
72	¾ mile north Robbins Reef.....	*p. m.* 12:10	5	1,280	+	+	+
73	¾ mile north Robbins Reef.....	*m.* 12:00	40	1,055	+	+	+
74	¾ mile north Robbins Reef.....	*a. m.* 11:55	80	595	+	+	+
75	Off Battery and Governor's Island, mid stream.....	*p. m.* 12:35	5	1,510	+	+	+
76	Off Battery and Governor's Island, mid stream.....	12:30	40	920	0	+	+
77	Off Battery and Governor's Island mid stream.....	12:20	80	760	+	+	+
78	Off Battery and Governor's Island, mid stream.....	3:15	5	1,200	+	+	+
79	Off Battery and Governor's Island, mid stream.....	3:10	40	740	+	+	+
80	Off Battery and Governor's Island, mid stream.....	3:00	80	540	0	+	+
81	¾ mile north Robbins Reef.....	3:40	5	930	0	+	+
82	¾ mile north Robbins Reef.....	3:32	40	750	0	+	+
83	¾ mile north Robbins Reef.....	3:26	80	420	0	0	+

D CLOSE IN CENTER

15 Tables 1 and 2 show that the numbers of bacteria were very much larger near the surface than in the water below. The reduction in the numbers with the depth is striking and indicates that most of the sewage, and other decomposable refuse with which the bacteria were associated, was flowing around at the surface and not mixing uniformly with the water. The tests for B. coli confirm the conclusions which might be derived from a study of the numbers of bacteria alone. There were more coli at the top of the water than in the water below.

In a very large majority of all the samples examined in the commission's investigations, the presumptive tests for coli have resulted positively. In a few cases they have resulted negatively at depths of 60 feet and over.

2. Bacterial Condition of the Gowanus Canal.

One of the most polluted arms of the Upper Bay is the Gowanus Canal on the Brooklyn shore. The odors from this canal constitute such a decided nuisance to the people who live and work in its vicinity that the City of New York has recently let contracts for the construction of pumping engines and a tunnel at an expense of about $275,000 to flush out this odorous canal.

In order to obtain an accurate idea of the data which this water would yield on analysis, chemical and bacteriological examinations were made of three samples of the canal water taken from different points between the outlet and the head of the canal. The results are given in table 3.

Table 3. Results of chemical and bacterial analyses of water taken from the Gowanus Canal. The samples were taken from a boat at a depth of one foot below the surface on February 3, 1906.

16

Map No.	Point of collection of sample.	Free ammonia.	Albuminoid ammonia.	Chlorine.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
84	Head of Gowanus Canal.	24.00	5.40	1,400	1,050,000	+	+	+
85	Below Union Street.....	5.60	2.16	5,900	190,000	+	+	+
86	Near Outlet	3.40	1.26	7,450	100,000	+	+	+

According to this table, there was a decided difference between the condition of the water of the canal at different points, but in no case was it satisfactory from a sanitary standpoint. The bacteria were enormously large in number, as were the amounts of free and albuminoid ammonia present. The tests for coli resulted positively in every case.

The condition of the Gowanus Canal, as shown by this table, of Bodine Creek and of the Rahway River, as given in table 5, and of the Bronx River, as given in table 6, indicate conditions which should serve as a warning of what the whole bay may become if it is not protected against unlimited pollution in the future.

COPY BOUND

3. Bacteria at Different Depths in the Lower Bay and Narrows.

The bacterial condition of the water of the Lower Bay and Narrows at different depths was investigated to determine whether there was any marked difference in the pollution at points below the surface as compared with the conditions at the top. The results are given in table 4.

Table 4. Results of bacterial analyses of water taken from various points at different depths in the Lower Bay and Narrows. The samples were collected from a boat on February 17, 1906, between 2:45 p. m. and 4:40 p. m. High water occurred at Sandy
17 Hook at 2:39 p. m., and at Governor's Island at 2:55 p. m. The wind was southwest to south and averaged 6½ miles per hour.

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		p. m.					
87	Off Norton's Point, Lower Bay.	3:30	5	1,045	0	+	+
88	Off Norton's Point, Lower Bay.	3:00	40	560	0	0	+
89	Off Norton's Point, Lower Bay.	2:45	80	225	0	0	+
90	Narrows	4:40	5	1,180	0	+	+
91	Narrows	4:25	40	545	0	+	+
92	Narrows	4:10	80	460	0	+	+

18

Table 4 shows that the water near the surface contained several times as many bacteria as the water near the bottom. The numbers of bacteria were not quite as large in the Lower Bay as in the Upper Bay, but the difference was slight. Not so many samples of deep water as surface water gave positive results in the coli tests.

4. Bacteria in Upper Bay and Lower Parts of the East and North Rivers.

In order to obtain further information concerning the bacterial condition of the water in the Upper Bay and lower ends of the East and North rivers, a series of examinations of these waters was made as shown in table 5.

Table 5. Results of bacterial analyses of water taken from various points in the Upper Bay and lower ends of the East and North rivers. The samples were collected from a boat on March 2, 1906, between 11:00 a. m. and 5:15 p. m. At Governors Island high tide occurred at 12:20 p. m., and low tide at 7:10 p. m. The wind was east and northeast and ranged from 5 to 9 miles per hour.

D CLOSE IN CENTER

18

Map No.	Point of collection of sample.	Time.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		a. m.				
93	Off Bath Beach, Brooklyn	11:00	4,100	+	+	+
94	Head of Lower Bay, off Fort Wadsworth, Narrows	11:10	3,380	+	+	+
95	Off Clifton, Staten Island, mid stream	11:15	3,100	+	+	+
96	Off Tompkinsville, Staten Island	11:25	3,580	+	+	+
97	West end of Kill von Kull	11:35	4,670	+	+	+
98	Off New Brighton, Staten Island, Kill von Kull	11:45	3,500	0	+	+
		m.				
99	Kill von Kull, off Sailors' Snug Harbor, Staten Island	12:00	3,800	0	+	+
		p. m.				
100	Kill von Kull, off Port Richmond, Staten Island	12:10	4,900	+	+	+
101	Northwest Robbins Reef Light	1:45	3,250	+	+	+
102	Northeast Robbins Reef Light	1:50	3,080	0	+	+
103	Midway between Robbins Reef and Liberty Island	1:55	3,200	+	+	+
104	Southwest of Liberty Island	1:57	5,910	+	+	+
105	Between Liberty Island and Claremont, New Jersey	2:00	6,800	+	+	+
106	Between Ellis Island and Liberty Island	2:05	5,120	0	+	+
107	Off Ellis Island	2:12	8,650	+	+	+
108	Northeast of Ellis Island	2:15	7,060	+	+	+
109	Off Central R. R. of N. J. Docks, N. J.	2:20	7,480	+	+	+
110	Off Penn. R. R. Docks, N. J.	2:30	5,100	+	+	+
111	Off Erie R. R. Docks, N. J.	2:45	5,350	+	+	+
112	Off D., L. & W. R. R. Docks, N. J.	2:55	4,300	0	+	+
113	North of Hoboken, N. J.	3:10	3,560	0	+	+
114	Off Weehawken, N. J.	3:25	3,120	0	+	+
115	Off American Line Dock, mid stream	3:35	5,410	+	+	+
116	Off Pier No. 4, North River, Manhattan	3:40	5,780	+	+	+
117	Off Battery, Manhattan	3:38	7,280	+	+	+
118	Off Pier No. 6, East River, Manhattan	3:45	14,100	+	+	+
119	Off Pier No. 13, East River, Manhattan	3:55	18,400	+	+	+
120	Off Pier No. 20, East River, Manhattan	3:58	12,600	+	+	+
121	Off Pier No. 28, East River, Manhattan	4:00	15,200	+	+	+
122	Off Pier No. 23, East River, Brooklyn	4:05	4,300	0	0	+
123	Off Atlantic Docks, Buttermilk Channel, Brooklyn	4:15	10,400	+	+	+
124	Off Beards, Erie Basin, Brooklyn	4:20	36,800	+	+	+
125	Off Gowanus Bay, Brooklyn	4:25	8,500	+	+	+
126	Off Gowanus and Hamilton ave. Bridge, Brooklyn	4:35	270,000	+	+	+
127	Between Hamilton ave. Bridge and outlet, ——, Brooklyn	4:40	180,000	+	+	+
128	Off Prince Line Dock, Brooklyn	4:50	24,300	+	+	+
129	Off 56th Street, Brooklyn	5:00	16,400	+	+	+
130	Off 65th Street, near sewer, Brooklyn	5:05	278,000	+	+	+
131	Off Crescent Club, Brooklyn	5:15	5,800	0	+	+
132	At oyster beds, mouth of Bodine Creek, Port Richmond	12:35	11,200	+	+	+
133	Bodine Creek, midway to head at crossing	12:30	11,500	+	+	+
134	Bodine Creek, upper end	12:25	15,800	+	+	+
135	Rahway river, below sewer outlet	12:30	8,500	+	+	+
136	Rahway River, N. J., over oyster beds	2:15	5,800	+	+	+

One of the most significant features of table 5 is the large proportion of positive results obtained in the tests for B. coli. Nearly every test resulted positively. The numbers of bacteria were comparatively large, in some cases decidely so. The greatest numbers were contained in samples taken within range of extensive local sources of pollution, such as the Gowanus Canal and the
19 large sewer which empties from the Brooklyn shore in the neighborhood of 65th street.

The East River contained many more bacteria than the North River or the Upper Bay—or even the Staten Island shore, which is one of the most polluted localities which have been investigated.

Samples of water were taken from Bodine Creek and the Rahway River, which latter empties into the Arthur Kill on the west side of Staten Island, in order to show the conditions of water in which oysters are extensively "drinked" in preparation for the New York market. Both streams were known from previous investigations to be decidely polluted with sewage. The conditions surrounding Bodine Creek were described in the first report of the New York Bay Pollution Commission. The Rahway River receives the sewage of the municipality of Cranford and the sewage of the city of Rahway.

The results of these examinations are given in table 5. In view of the known pollution of these two streams, it seems a little curious that the numbers of bacteria were not larger.

5. Bacterial Condition of the Lower Bronx River.

Notwithstanding the fact that some effort has been made to protect the lower part of the Bronx River against sewage pollution, the condition of that stream is far from satisfactory. Samples of water were taken at different points below the dam toward the mouth of the Bronx River with results which are given in table 6.

Table 6. Results of chemical and bacterial analyses of water taken from various points in the Bronx River at a depth of one foot below the surface. The samples were collected from a boat on March 31, 1906, between 3:00 and 4:30 p. m. High water occurred at
20 Willett's Point at 3:20 p. m. The wind was northwest and averaged 31 miles per hours. (Results stated in parts per million.)

Map No.	Point of collection of sample.	Free ammonia.	Albuminoid ammonia.	Chlorine.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	0.1 c. c.	10 c. c.
137	Bronx River, below dam	.300	.250	50	14,800	+	+	+
138	Bronx River, at mouth.	.310	.340	5,200	9,500	+	+	+
139	Bronx River, between mouth and Hunts Point	.250	.530	6,600	7,200	+	+	+
140	Bronx River, off Hunts Point	.240	.260	13,500	3,400	+	+	+

NOTE.—The following figures give the number of cubic centimeters of dissolved oxygen per litre found in these samples: No. 137, 8.62 c. c. oxygen; No. 138, 9.28 c. c. oxygen; No. 139, 7.07 c. c. oxygen; No. 140, 9.61 c. c. oxygen.

The numbers of bacteria given in this table show diminishing pollution as the river approaches its mouth. From the dam to the mouth of the river the reduction in the numbers of bacteria was decided. The differences in the amounts of free and albuminoid ammonia were not so noticeable, but there was a progressive reduction in the free ammonia which confirms the bacterial results. It is interesting to note that all of the tests for B. coli gave positive results.

6. Bacteria in the Rivers Surrounding Manhattan Island.

A series of analyses was made to determine the bacterial condition of the Hudson, East and Harlem rivers. The results of these examinations are given in table 7.

Table 7. Results of bacterial analyses of water taken from various points in the waters surrounding Manhattan Island. The samples were collected from a boat on April 1, 1906, between 9:55 a. m. and 3:05 p. m., at a depth of one foot below the surface, unless otherwise indicated. High water occurred at Governors
21 Island at 12:30 p. m. The tide was low at Governors Island at 7:16 a. m., and at Willetts Point at 10:13 a. m. The wind was northwest and ranged from 17 to 32 miles per hour.

Map No.	Point of collection of sample.	Time.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		p. m.				
141	Hudson River, opposite Spuyten Duyvil	12:42	3,550	+	+	+
142	Hudson River, north of Fort Washington Point	12:50	2,230	+	+	+
143	Hudson River, south of Fort Washington Point	1:05	2,310	+	+	+
144	Hudson River, off Grant's tomb, bottom	1:15	3,210	+	+	+
145	Hudson River, off Grant's tomb, surface	1:20	2,640	0	+	+
146	Hudson River, off West 80th Street	2:45	2,990	+	+	+
147	Hudson River, off West 40th Street	3:05	4,080	+	+	+
		a. m.				
148	East River, off Battery, bottom	9:55	4,280	+	+	+
149	East River, off Battery, surface	10:00	6,250	+	+	+
150	East River, Pier No. 15	10:05	4,410	+	+	+
151	East River, under Manhattan bridge	10:10	8,460	+	+	+
152	East River, below Blackwell's Island, bottom	10:40	8,320	+	+	+
153	East River, below Blackwell's Island, surface	10:45	8,940	+	+	+
154	East River, above Blackwell's Island	11:05	9,120	+	+	+
155	East River, off Randall's Island	11:20	8,740	+	+	+
156	Harlem River, first bridge	11:30	7,200	+	+	+
157	Harlem River, third bridge	11:35	3,640	+	+	+
158	Harlem River, fifth bridge, Madison avenue	11:40	3,290	+	+	+
159	Harlem River, seventh bridge	11:45	2,970	0	+	+
160	Harlem River, Highbridge, bottom	11:50	2,760	0	0	+
161	Harlem River, Highbridge, surface	11:55	3,530	+	+	+

Map No.	Point of collection of sample.	Time.	Bacteria per c. c.	Tests for B. Coli. 0.1 c. c.	1.0 c. c.	10 c. c.
		p. m.				
162	Harlem River, above Washington bridge	12:05	3,675	0	+	+
163	Harlem River, opposite N. Y. University	12:15	1,080	0	0	+
164	Harlem River, Broadway bridge	12:25	2,400	0	+	+
165	Harlem River, bend of river between last two bridges	12:35	2,310	0	0	0
166	Harlem River, N. Y. Central bridge.	12:40	2,340	0	0	0

Nearly all of the samples recorded in the foregoing table gave positive results in the presumptive test for B. coli. The only exception was in water from the Harlem River. The condition of the Harlem appears to have been much better than either that of the East or Hudson River, although the numbers of bacteria were in no case low, considering the season of the year when the samples were collected. The East River was decidedly more polluted than either the Hudson or Harlem. The average of the numbers of bacteria was more than twice as high in the East River as in the other two rivers.

The water near the bottom of the East River near the Battery contained about as many bacteria as the water at the surface at this point.

22 The Hudson from its junction with the Harlem to 40th street was, like the East River, decidedly polluted.

B—Results of Chemical Analyses.

1. Chemical Condition of Water from Different Depths in the Upper Bay.

Samples of water from different depths at points between the Battery and the Narrows were analyzed chemically to determine whether the evidence so obtained would show any difference in the conditions. The results are given in tables 8 and 9.

Table 8. Results of chemical analyses of water taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 28, 1906, between 10:00 a. m. and 3:30 p. m. At Governor's Island the tide was high at 10:40 a. m., and low at 5:12 p. m. The wind was north to northwest with a minimum velocity of 4 miles per hour between noon and 1:00 p. m., and 13 miles per hour between 3:00 and 4:00 p. m. (Results stated in parts per million).

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		a. m.				
51	Narrows opposite Fort Hamilton..	10:00	5	.182	.192	10,650
52	Narrows opposite Fort Hamilton..	10:10	40	.158	.162	12,600
53	Narrows opposite Fort Hamilton..	10:15	80	.152	.160	14,000
54	⅜ mile north Robbins Reef.....	10:53	5	.196	.136	8,800
55	⅜ mile north Robbins Reef.....	11:15	40	.178	.150	12,600
56	⅜ mile north Robbins Reef.....	10:58	80	.186	.168	12,400
		p. m.				
57	Off Battery and Governor's Island, mid stream	2:40	*	....	....	9,700
58	Off Battery and Governor's Island, mid stream	2:30	5	.300	.224	10,200
59	Off Battery and Governor's Island, mid stream	2:35	20	....	....	10,900
60	Off Battery and Governor's Island, mid stream	2:22	40	.180	.164	11,700
61	Off Battery and Governor's Island, mid stream	2:28	60	....	....	12,800
62	Off Battery and Governor's Island, mid stream	2:15	80	.174	.210	12,900
63	⅜ mile north Robbins Reef.....	3:05	5	.222	.146	9,100
64	⅜ mile north Robbins Reef.....	3:57	40	.254	.142	13,100
65	⅜ mile north Robbins Reef.....	2:45	80	.160	.140	13,200
66	Narrows	3:21	5	.206	.150	9,400
67	Narrows	3:24	40	.210	.168	10,400
68	Narrows	3:30	80	.214	.230	12,800

* At surface.

23 Table 9. Results of chemical analyses of water taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 30, 1906, between 11:00 a. m. and 3:40 p. m. High water occurred at Governor's Island at 12:05 p. m. The wind was south and varied from 10 to 15 miles per hour. (Results stated in parts per million).

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		a. m.				
69	Narrows opposite Fort Hamilton..	11:12	5	.186	.126	10,900
70	Narrows opposite Fort Hamilton..	11:05	40	.144	.126	13,700
71	Narrows opposite Fort Hamilton..	11:00	80	....	....	14,500
		p. m.				
72	⅝ mile north Robbins Reef.....	12:10	5	.204	.134	10,500
		m.				
73	⅝ mile north Robbins Reef.....	12:09	40	.186	.156	11,700
		a. m.				
74	⅝ mile north Robbins Reef.....	11:55	80	.156	.174	12,800
		p. m.				
75	Off Battery and Governor's Island, mid stream	12:35	5	.194	.156	7,600
76	Off Battery and Governor's Island, mid stream	12:30	40	.198	.146	11,600
77	Off Battery and Governor's Island, mid stream	12:20	80	.150	.146	12,700
78	Off Battery and Governor's Island, mid stream	3:15	5	.220	.146	9,100
79	Off Battery and Governor's Island, mid stream	3:10	40	.140	.134	13,100
80	Off Battery and Governor's Island, mid stream	3:00	80	.142	.144	13,200
81	⅝ mile north Robbins Reef.....	3:40	5	.190	.134	10,400
82	⅝ mile north Robbins Reef.....	3:32	40	.156	.146	12,400
83	⅝ mile north Robbins Reef.....	3:26	80	.154	.152	12,500

The analyses recorded in these two tables show that there was a reduction in the amount of albuminoid and free ammonia in the water as the depth from the surface increased. In some cases this difference was very decided; in others it was less marked. An average of all the results indicates that the water near the surface was much more polluted than the water below.

It is interesting to observe in this table that the chlorine invariably increased with the depth, showing that there was a larger percentage of sea water at the bottom than at the surface. Reasons for believing that this was the case were given in the first report of the New York Bay Pollution Commission.

2. Chemical Condition of the Water at Different Depths in the Lower Bay and Narrows.

In order to show the difference in the amount of pollution which might exist in the water at different depths in the Lower Bay, a series of samples was collected near Coney Island and the Narrows. The results are given in table 10.

Table 10. Results of chemical analyses of water taken at various points at different depths in the Lower Bay and Narrows. The samples were collected from a boat on February 17, 1906, between 2:45 and 4:40 p. m. High water occurred at Sandy Hook at 2:39 p. m., and at Governor's Island at 2:55 p. m. The wind was southwest to south and averaged 6½ miles per hour. (Results stated in parts per million.)

Map No.	Point of collection of sample.	Time.	Depth below surface in feet.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		p. m.				
87	Off Norton's Point, Lower Bay....	3:30	5	.250	.275	12,500
88	Off Norton's Point, Lower Bay....	3:00	40	.280	.180	15,300
89	Off Norton's Point, Lower Bay....	2:45	80	.250	.280	15,500
90	Narrows	4:40	5	.260	.200	12,800
91	Narrows	4:25	40	.130	.130	14,400
92	Narrows	4:10	80	.275	.275	14,800

Table 10 shows that the extent of the pollution did not, in this case, vary inversely as to depth. There were larger amounts of free and albuminoid ammonia near the surface and at the bottom than in the middle. These differences were marked. It appeared that a stratum of water containing more sewage than was found in the Upper Bay lay at the top and bottom, while the water between was in a somewhat less contaminated condition.

The chlorine results show that the water was considerably salter at the bottom than at the top.

These chemical conditions formed an exception to the rule which had been observed thus far, that is, that there was more sewage at the surface than below.

3. Chemical Condition of Water of New York Bay and Lower Ends of East and North Rivers.

Samples of water were taken at different points in the vicinity of the Upper Bay and analyzed chemically with the results given in table 11.

Table 11. Results of chemical analyses of water taken from various points in the Upper Bay and lower ends of the East and North rivers. The samples were collected from a boat on March 2, 1906, between 11:00 a. m. and 5:15 p. m. At Governors Island high water occurred at 12:20 p. m., and low water at 7:10 p. m. The wind was east and northeast and ranged from 5 to 9 miles per hour. (Results stated in parts per million.)

Map No.	Point of collection of sample.	Time.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		a. m.			
95	Off Ruth Beach, Brooklyn	11:00	.....	.....	10,000
96	Head of Lower Bay, off Fort Wadsworth Narrows	11:10	.....	.....	9,000
97	Off Clifton, Staten Island, mid stream	11:15	.....	.....	6,700
98	Off Tompkinsville, Staten Island	11:25	.300	.200	6,500
97	West end of Kill von Kull	11:25	.380	.200	7,100
99	Off New Brighton, Staten Island, Kill von Kull	11:45	.....	.....	7,000
99	Kill von Kull off Sailors Snug Harbor, Staten Island	12:00 m.	.....	.....	7,100
100	Kill von Kull, off Fort Richmond, Staten Island	12:10 p. m.	.270	.250	7,000
101	Northwest Robbins Reef Light	1:45	.340	.210	6,000
102	Northeast Robbins Reef Light	1:50	.....	.....	6,300
103	Midway between Robbins Reef and Liberty Island	1:55	.....	.....	6,900
104	Southwest of Liberty Island	1:57	.340	.190	5,300
105	Between Liberty Island and Claremont, N. J.	2:00	.....	.....	5,700
106	Between Ellis Island and Liberty Island	2:05	.....	.....	6,000
107	Off Ellis Island	2:12	.....	.....	5,700
108	Northeast of Ellis Island	2:15	.370	.220	6,000
109	Off C. R. R. of N. J. Docks, N. J.	2:20	.400	.210	6,700
110	Off Penn. R. R. Docks, N. J.	2:30	.....	.....	6,200
111	Off Erie R. R. Docks, N. J.	2:45	.....	.....	6,000
112	Off D., L. & W. R. R. Docks, N. J.	2:55	.330	.240	5,200
113	North of Hoboken, N. J.	3:10	.....	.....	5,100
114	Off Weehawken, N. J.	3:25	.330	.200	4,900
78		p. m.			
115	Off American Line Dock, mid stream	3:25	.....	.....	7,000
116	Off Pier No. 4, North River, Manhattan	3:40	.....	.....	7,500
117	Off Battery, Manhattan	3:50	.300	.280	8,200
118	Off Pier No. 6, East River, Manhattan	3:45	.....	.....	8,400
119	Off Pier No. 13, East River, Manhattan	3:55	.410	.240	8,600
120	Off Pier No. 20, East River, Manhattan	3:58	.370	.230	8,800
121	Off Pier No. 28, East River, Manhattan	4:00	.520	.490	8,400
122	Off Pier No. 23, East River, Brooklyn	4:05	.....	.....	8,600
123	Off Atlantic Docks, Buttermilk Channel, Brooklyn	4:15	.400	.250	8,600
124	Off Beards, Erie Basin, Brooklyn	4:20	.....	.....	8,600
125	Off Gowanus Bay, Brooklyn	4:25	.740	.350	8,600
126	Off Gowanus and Hamilton ave. bridge, Brooklyn	4:35	7.000	1.110	6,800
127	Between Hamilton ave. bridge and outlet, Brooklyn	4:40	.....	.....	8,500
128	Off Prince Line Dock, Brooklyn	4:50	.....	.....	8,400
129	Off 50th street, Brooklyn	5:00	.....	.....	7,900
130	Off 65th st., near sewer, Brooklyn	5:05	3.700	1.430	6,500
131	Off Crescent Club, Brooklyn	5:15	.....	.....	8,000
132	At oyster beds mouth of Bodine Creek, Port Richmond	12:25	.465	.260	5,000
133	Bodine Creek, midway to head at crossing	12:30	.400	.240	2,000
134	Bodine Creek, upper end	12:25	.330	.280	490
135	Rahway River, N. J., below sewer outlet	12:30	.280	.320	6
136	Rahway River, N. J., over oyster beds	2:15	.270	.310	240

3155

On the occasion when the samples were collected for table 11, there was a larger amount of sewage in the water than had been observed previously. Some of the samples, although not collected near obvious sources of pollution, contained relatively large amounts of free ammonia. The water in the lower end of the East River was notable in this respect.

4. Chemical Condition of the Waters of the Rivers Surrounding Manhattan Island.

Samples of water taken from the East River, Harlem River and Hudson River were analyzed chemically with the results given in table 12.

Table 12. Results of chemical analyses of water taken from various points in the waters surrounding Manhattan Island. The samples were collected from a boat at a depth of one foot below the surface, unless otherwise indicated, on April 1, 1906, between 9:55 a. m. and 3:05 p. m. High water occurred at Governors Island at 12:30 p. m. The tide was low at Governor's Island at 7:16 a. m. and at Willetts Point at 10:13 a. m. The wind was northwest and ranged from 17 to 32 miles per hour. (Results stated in parts per million.)

Map No.	Point of collection of sample.	Time.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		p. m.			
141	Hudson River, opposite Spuyten Duyvil.	12:42	.150	.220	290
142	Hudson River, north of Fort Washington Point	12:50	.190	.210	250
143	Hudson River, south of Fort Washington Point	1:05	.150	.190	810
144	Hudson River, off Grant's tomb, bottom	1:15	.250	.240	7,700
145	Hudson River, off Grant's tomb, surface	1:20	.230	.300	510
146	Hudson River, off West 80th street	2:45	.170	.250	990
147	Hudson River, off West 40th street	3:05	.260	.250	1,150
		a. m.			
148	East River, off Battery, bottom	9:55	.310	.270	11,800
149	East River, off Battery, surface	10:00	.320	.270	6,100
150	East River, off Pier No. 15	10:05	.....	.....	4,800
151	East River, under Manhattan bridge	10:10	.490	.320	9,600
152	East River, below Blackwell's Island, bottom	10:40	.380	.290	11,900
153	East River, below Blackwell's Island, surface	10:45	.500	.360	10,900
154	East River, above Blackwell's Island	11:05	.360	.370	12,300
155	East River, off Randall's Island	11:20	.870	.720	10,900
156	Harlem River, first bridge	11:30	.410	.450	8,700
157	Harlem River, third bridge	11:35	.....	.....	7,800
158	Harlem River, fifth bridge, Madison ave.	11:40	.330	.320	7,100
159	Harlem River, seventh bridge	11:45	.....	.....	4,300
160	Harlem River, Highbridge, bottom	11:50	.170	.220	1,400
161	Harlem River, Highbridge, surface	11:55	.270	.250	1,300

Map No.	Point of collection of sample.	Time.	Free ammonia.	Albuminoid ammonia.	Chlorine.
		p. m.			
162	Harlem River, above Washington bridge	12:05	.....	.....	900
163	Harlem River, opposite N. Y. University	12:15	.....	.....	800
164	Harlem River, Broadway bridge	12:25	.140	.230	650
165	Harlem River, bend of river between last two bridges	12:35	.....	.....	600
166	Harlem River, N. Y. Central bridge	12:40	.250	.170	600

The water of the East River contained, on an average, more free and albuminoid ammonia than the waters of the Hudson or Harlem rivers. It was, therefore, decidedly more polluted.

There was little difference between the water at the surface and at the bottom, so far as the ammonias indicated.

There was much more sea water in the East River than in the Hudson or Harlem rivers.

The condition of the Harlem River, as indicated by these analyses, was not far different from that of the Hudson.

The results of the determinations of chlorine show that the Hudson River was comparatively fresh as far south as the middle of Manhattan Island, except at the bottom. There was much more salt water near the bottom than at the top. A sample collected near the bottom, off Grant's Tomb, contained about thirteen times as much chlorine as the average of the surface samples above 40th street.

Off the Battery there was nearly twice as much sea water at the bottom as at the top.

There was a steady decrease in the amount of salt water in the Harlem River from the East River to the Hudson.

4. Amount of Oxygen Found in the Waters of New York Bay and Vicinity.

Inasmuch as the digestion of sewage in the tidal waters about New York depends largely upon their supply of oxygen, a series of analyses was made to determine whether these waters contained as much oxygen as they should have. Tables 13, 14 and 15 give the results of the oxygen determinations at different depths in the waters of the Upper and Lower bays.

Table 13. Results of analyses of water for oxygen taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 28, 1906, between 10:00 a. m. and 3:30 p. m. At Governors Island the tide was high at 10:40 a. m., and low at 5:12 p. m. The wind was north to northwest with a minimum velocity of 4 miles per hour, between noon and 1:00 p. m., and 13 miles per hour between 3:00 and 4:00 p. m. (Results stated in cubic centimeters of oxygen per litre of water.)

Map. No.	Point of collection of sample.	Time.	Depth below surface in feet.	Oxygen.
		a. m.		
51	Narrows opposite Fort Hamilton	10:00	5	6.49
51	Narrows opposite Fort Hamilton	10:10	40	7.14
53	Narrows opposite Fort Hamilton	10:15	80	6.27
54	¾ mile north Robbins Reef	10:53	5	7.45
		p. m.		
58	Off Battery and Governor's Island, mid stream	2:30	5	7.24
63	¾ mile north Robbins Reef	3:05	5	7.68
65	¾ mile north Robbins Reef	2:45	80	7.15
66	Narrows	3:21	5	7.47

29 Table 14. Results of analyses of water for oxygen taken from various points at different depths in Upper New York Bay. The samples were collected from a boat on January 30, 1906, between 11:00 a. m. and 3:40 p. m. High water occurred at Governors Island at 12:05 p. m. The wind was south and varied from 10 to 15 miles per hour. (Results stated in cubic centimeters of oxygen per litre of water.)

Map. No.	Point of collection of sample.	Time.	Depth below surface in feet.	Oxygen.
		a. m.		
69	Narrows opposite Fort Hamilton	11:12	5	8.82
70	Narrows opposite Fort Hamilton	11:05	40	7.31
71	Narrows opposite Fort Hamilton	11:00	80	7.16
		p. m.		
72	¾ mile north Robbins Reef	12:10	5	9.19
		p. m.		
75	Off Battery and Governor's Island, mid stream	12:35	5	8.51
78	Off Battery and Governor's Island, mid stream	3:15	5	8.63
81	¾ mile north Robbins Reef	3:40	5	7.38

Table 15. Results of analyses of water for oxygen taken from various points at different depths in the Lower Bay and Narrows. The samples were collected from a boat on February 17, 1906, between 2:45 p. m. and 4:40 p. m. High water occurred at Sandy Hook at 2:39 p. m., and at Governors Island at 2:55 p. m. The wind was southwest to south and averaged 6½ miles per hour. (Results stated in cubic centimeters of oxygen per litre of water.)

Map. No.	Point of collection of sample.	Time.	Depth below surface in feet.	Oxygen.
		p. m.		
87	Off Norton's Point, lower bay	3:30	5	7.16
88	Off Norton's Point, lower bay	3:00	40	7.46
89	Off Norton's Point, lower bay	2:45	80	8.13
90	Narrows	4:40	5	6.71
91	Narrows	4:25	40	7.68
92	Narrows	4:10	80	6.86

30 The three foregoing tables show that there was always enough oxygen in the water to insure a sufficient supply for the bacteria of decomposition. Under such circumstance no offensive odors would be formed by them.

In many cases the amount of oxygen increased with the depth. Samples taken near the surface usually did not have as much oxygen as samples from below. This was contrary to what might have been expected and seems to show that the disproportionately large numbers of bacteria of decomposition which exist near the surface consume enough of the oxygen to visibly reduce its amount.

Oxygen determinations were also made of samples of water collected at the surface at a number of other points in the vicinity of New York. The results are given in tables 16 and 17.

Table 16. Results of analyses of water for oxygen taken from various points in the Upper Bay and lower ends of the East and North rivers. The samples were collected from a boat on March 2, 1906, between 11:25 a. m. and 5:05 p. m. At Governors Island high water occurred at 12:20 p. m., and low water at 7:10 p. m. The wind was east and northeast and ranged from 5 to 9 miles per hour. (Results stated in cubic centimeters of oxygen per litre of water.)

Map No.	Point of collection of sample.	Time.	Oxygen.
		a. m.	
96	Off Tompkinsville, Staten Island	11:25	7.94
97	West end of Kill von Kull	11:35	7.52
		p. m.	
100	Kill von Kull, off Port Richmond, Staten Island	12:10	6.69
107	Off Ellis Island	2:12	6.79
113	North of Hoboken, N. J.	3:10	7.61
114	Off Weehawken, N. J.	3:25	7.62
121	Off Pier No. 28, East River, Manhattan	4:00	6.98
123	Off Atlantic Docks, Buttermilk Channel, Brooklyn	4:15	6.54
125	Off Gowanus Bay, Brooklyn	4:25	5.63
126	Off Gowanus and Hamilton ave. bridge, Brooklyn	4:35	.00
130	Off 65th st., near sewer, Brooklyn	5:05	4.86
134	Bodine Creek, upper end	12:25	7.50

31 Table 17. Results of analyses of water for oxygen taken from various points in the waters surrounding Manhattan Island. The samples were collected from a boat on April 1, 1906, between 9:55 a. m. and 1:15 p. m. High water occurred at Governors Island at 12:30 p. m. The tide was low at Governors Island at 7:16 a. m., and at Willett's Point at 10:13 a. m. The wind was

Map No.	Point of collection of sample.	Time.	Oxygen.
		p. m.	
144	Hudson River, off Grant's tomb, bottom	1:15	8.80
145	Hudson River, off Grant's tomb, surface	1:20	9.15
		a. m.	
148	East River, off Battery, bottom	9:55	8.62
149	East River, off Battery, surface	10:00	8.84
152	East River, below Blackwell's Island, bottom	10:40	8.29
153	East River, below Blackwell's Island, surface	10:45	8.07

northwest and ranged from 17 to 32 miles per hour. (Results stated in cubic centimeters of oxygen per litre of water.)

It will be observed that the oxygen was exhausted in only one of the samples examined, that is, in that one which was collected from the Gowanus Canal. There was a decided reduction below the average in the amount of oxygen in the water of the bay opposite the outlet of the Gowanus Canal and also near the outfall of the large trunk sewer at 65th street, Brooklyn. This showed the effect of sewage contamination.

In samples collected in the Hudson River and East River there was no deficiency of oxygen.

The difference between the oxygen at the bottom and near the surface of the water was noticeable in the Hudson off Grant's Tomb. Here there was more oxygen at the surface than at the bottom.

32 C—Results of a Sanitary Inspection of the Shores of New York Bay.

An inspection of the shores of New York Bay was undertaken in the latter part of March and continued until the middle of April, 1906. The object of this inspection was to observe such sewage or other pollution as might exist on or near the shores. A sanitary inspector, Dr. Payne B. Parsons, walked along the shore line and made note of sewage and refuse on the shores and in the water within his range of view.

The conditions found are given in the following tables.

Table 18. Results of a sanitary inspection of the Staten Island shore of New York bay.

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906. Mar. 27	a. m. 10:15	Midland Beach	S. W.	Ebb	Driftwood (large amount), tin cans, bottles, crockery, bones, shoes, rags, paper, shells, vegetables, dead animals, straw and fibrous material, seaweed, etc. Offensive odor.
Mar. 27	11:30	South Beach, about 100 yards of lower part.	S. W.	Ebb	In 400 square feet of shore about 1-20 cubic yard of vegetable matter, 1-20 cubic yard of animal matter and 1-2 cubic yard wood.
Mar. 27	p. m. 2:00	South Beach to Fort Wadsworth.	S.	Ebb	In 400 sq. ft. of shore about 1-30 cu. yd. of vegetable matter, 1-30 cu. yd. of animal matter and 1-2 cu. yd. of driftwood.
Mar. 28	a. m. 9:30	From upper (northern) limit of Fort Wadsworth north 100 yds.	N. W.	Flood.	Large amount of driftwood. Much less general refuse than at South Beach. Very little garbage. Two dead animals.
Mar. 28	10:00	Last point to foot of Cliff street, Rosebank.	N. W.	Flood.	Much driftwood, bottles, rags, cans, etc. Not much garbage.
Mar. 28	10:40	Foot of Cliff street to foot Pennsylvania ave., Rosebank.	N. W.	Ebb	Same as preceding.
Mar. 28	11:20	South of Doyle's wharf, about 200 yds. north of Pennsylvania ave.	N.	Ebb	Not much driftwood or garbage. Considerable amount of grease floating in water. Water polluted with a considerable amount of sewage. Nearest sewer foot West street, 100 yds. away. Did not appear from tide and wind to come from this.
Mar. 28	p. m. 12:05	Foot West st., Clifton	N. W.	Ebb	Much driftwood. Not much garbage. Surface of water covered with petroleum. Large sewer outlet here did not appear to change appearance of water. Odor very offensive from number of small sewers opening at side of street, 100 ft. from the shore. In 400 sq. ft. about 1-2 cu. yd. vegetable and 1-10 cu. yd. animal. No driftwood.
Mar. 29	a. m. 9:15	Foot of Dock st., Stapleton.	N.	Flood.	Grease and petroleum floating near shore. Driftwood, garbage, mattresses, house sweepings and formed fecal matter, the latter breaking up as it was observed, indicating that the sewage mostly came from sewer emptying at foot of street.
Mar. 29	10:00	Foot of Thompson st.	N.	Flood.	Same as preceding. Sewer emptied here. Sewage probably from this sewer.
Mar. 29	10:20	Foot of Canal st.	N. W.	Flood.	Several small sewers located here. Same conditions as above.
Mar. 29	10:40	Foot of Water st.	N. W.	Ebb	Two large sewers near together. Water covered with grease and sewage. Shore covered with sewage and general refuse. Formed feces in water and on shore. Great quantity of street sweepings and refuse from grain mill nearby. Odor offensive. Worst place found so far. No driftwood. In 400 sq. ft. of shore 1 cu. yd. vegetable matter and 1-10 cu. yd. animal matter.

Table 18.—*(Concluded.)*

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906	a. m.				
Mar. 29	11:30	Foot of Prospect st.....	N.....	Ebb...	Pier being made by dumping; some refuse falling over sides. Large sewer here, also. In 400 sq. ft. of shore about 1-5 cu. yd. vegetable, and 1-10 cu. yd. animal matter. Hardly any driftwood.
Mar. 29	m. 12:00	Foot of Wave st.....	N.....	Ebb...	Shore much cleaner. Some petroleum and grease on water.
Mar. 29	p. m. 12:15	Williams' lumber yard..	N. W..	Ebb...	Scum of grease, straw and wood about docks; large sewer. Water contains sewage, including formed feces. On shore, in 400 sq. ft., about 1-5 cu. yd. vegetable and 1-10 cu. yd. animal matter.
Mar. 29	1:30	Foot of Marietta st., Tompkinsville.	N. W..	Ebb...	Very large sewer. Water contains sewage near shore. In 400 sq. ft., about 1-5 cu. yd. vegetable and 1-10 cu. yd. animal matter; all this from sewer, apparently.
Mar. 29	2:15	Docks of Amer. Dock Stores, Tompkinsville	N. W..	Ebb...	Along docks saw some sewage, trace of garbage, fibrous matter and wood.
Mar. 29	3:00	Foot of South st., St. George.....	N. W..	Ebb...	Kerosene on water, also wood, fibre and some garbage.
Mar. 30	a. m. 9:20	Ferry Docks, St. George.	E.....	Flood.	Scum of grease and kerosene, fibrous material, garbage, wood, etc., floating about the docks. No odor. No sewage noticed.
Mar. 31	9:20	B. & O. Docks, St. George.	N. W..	Flood.	Petroleum, wood, straw and some garbage along docks.
Mar. 31	9:50	Foot Church st., New Brighton.	N. W..	Flood.	Petroleum and some driftwood.
Mar. 31	10:20	Foot Westervelt ave., New Brighton.	N.....	Flood.	Sewer here. Sewage from this, also petroleum. Some garbage and wood in water. Estimated 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter in 400 sq. ft. Two sewers here. Sewage on shore and in water from this sewer.
Mar. 31	11:30	Foot Tyson st., New Brighton.	N.....	Ebb...	Sewer here. Shore same as Lafayette st.
Mar. 31	11:50	Snug Harbor Dock....	N.....	Ebb...	Petroleum from Bayonne shore along dock. Some garbage and wood.
Mar. 31	p. m. 12:10	Between Snug Harbor and Livingston.	N. W..	Ebb...	Large open sewer empties into inlet. Shore of inlet lined with sewage, garbage, rags, paper and wood. 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter in 400 sq. ft.
Mar. 31	12:30	Club house Dock, Richmond Terrace.	N. W..	Ebb...	Petroleum and wood. No sewage.
Mar. 31	1:50	Foot Tompkins place, West New Brighton. Inlet from Tompkins place to Duncan st.	N. W..	Ebb...	Sewers open into inlet made by new railroad filling. Shore and water of inlet filthy. Odor offensive. ½ cu. yd. vegetable and 1-20 cu. yd. animal matter in 400 sq. ft.
Mar. 31	2:35	Bodine Creek, Port Richmond, near corner Richmond Terrace and Jewett ave.	N. W..	Ebb...	Shores of brook full of sewage. Many sewers empty into it. Garbage on shore. Odor offensive. Water full of sewage. Scum of grease and petroleum. Drinking ground for oysters. 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter on shore in 400 cu. ft.
Mar. 31	3:40	Port Richmond ave., Port Richmond, Bergen Beach ferry docks.	N. W..	Ebb...	Petroleum. Some garbage, wood, straw, etc. No sewage noticed.

This table shows that the Staten Island shore accumulates considerable quantities of refuse which is carried to it by the tide. Some portions of the shore are decidedly foul with sewage which is discharged by sewers from Staten Island itself.

Table 19. Results of a sanitary inspection of the New Jersey shore of New York bay.

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	a. m.				
Apr. 2	9:50	Bergen Point, Bayonne.	N. W..	Flood.	Some wood. No garbage or sewage.
Apr. 2	10:20	Foot of Hobart ave., Bayonne.	N. W..	Flood.	Rocky shore. No garbage or sewage.
Apr 2.	11:10	East end of Standard oil tanks, Bayonne	N. W..	Flood.	Petroleum on water and shore, wood. Two dead animals. About 1-30 cu. yd. vegetable and 1-40 cu. yd. animal matter in 400 sq. ft. of shore.
Apr. 2	11:35	Bayonne Yacht Club....	N. W..	Flood.	Rocky shore. No sewage or garbage. Petroleum on water.
Apr. 2	p. m. 1:05	Shore near Bayonne station, Lehigh Valley Railroad.	N. W..	Flood.	Two sewers here, 4 ft. in diameter each. Water discolored with sewage within radius of 100 yds. Also petroleum on water. Some wood and garbage, pipes, rags, etc. on shore. About 1-40 cu. yd. vegetable and 1-80 cu. yd. animal in 400 sq. ft. of shore.
Apr. 2	2:10	Foot 46th st., Bayonne.	N. W..	Ebb...	Shore free from garbage. No sewage noticed. Some wood and petroleum on water.
Apr. 3	a. m. 9:40	Foot East 49th st., Bayonne.	N. W..	Flood.	Large brick sewer here ending at high water mark. Sewage flows over beach, tide being low. Some refuse on shore. In 400 sq. ft. of shore, 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter. Odor 500 ft. leeward.
Apr. 3	10:20	Midway between 49th st. and Penn. Railroad wharf.	N. W..	Flood.	No trace of sewage. Some refuse In 400 sq. ft. of shore, about 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter.
Apr. 3	11:10	Penn. Railroad freight ferry house at end of point.	N. W..	Flood.	Scum of sewage on water from large sewer nearby. Some garbage and wood in water about dock.
Apr. 3	11:30	Penn. Railroad wharf...	N. W..	Flood.	A 5 ft. iron sewer runs out nearly to end of point on north side parallel to shore. Sewage from this sewer on shore and in water toward end of wharf. Odor not offensive on wharf.
Apr. 3	12:10	Shore opposite Bay View Cemetery, Greenview.	N. W..	Flood.	Large sewer (4 ft. iron) empties here. Runs over flats (swampy); could not reach end of it at shore.
Apr. 3	a. m. 12:20	Cavan's Point.....	N. W..	Flood.	No odor at railroad tracks. Cavan's Point shore free from garbage and sewage as far as could be seen.
Apr. 3	1:40	End of National docks, Point nearest Liberty Island.	N. W..	Flood.	Some driftwood along dock. No garbage; no sewage.

Table 19.—(*Concluded.*)

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906. Apr. 3	p. m. 2.15	Shore of Point opposite Ellis Island.	N. W.	Flood.	Some garbage, driftwood and petroleum on surface of water. In 400 sq. ft. of shore 1-30 cu. yd. vegetable and 1-60 cu. yd. animal matter.
Apr. 3	3.20	Shore between National docks and Communipaw.	W.	Ebb.	Garbage, paper and wood along docks. No sewage found.
Apr. 4	a. m. 9.25	Foot of Communipaw ave.	S. W.	Ebb.	Small sewer. Scum of grease on water. Sewage on shore. Odor had 200 ft. to leeward. No garbage.
Apr. 4	9.50	200 yds. north of Communipaw ave., along shore.	S. W.	Ebb.	A 2 ft. iron pipe empties between flats 100 ft. from shore. Runs from dredger 1 mile away, 150 yds. west of Ellis Island. Pipe discharges from free end and from cracks, sewage with coal from bottom of bay. Sewage has offensive odor. Whitish, greasy.
Apr. 4	11.05	Shore opposite Ellis Island, Jersey City.	S. W.	Flood.	Scum of grease on surface of water. Sewage on shore apparently stirred up by dredging near nearby.
Apr. 4	p. m. 12.10	Shore beside North River Coal Co. wharf, Jersey City.	S. W.	Flood.	Scum of grease on water. Odor of sewage 50 ft. to leeward. No garbage. Hardly any sewage on shore.
Apr. 4	1.45	Freight docks Central Railroad of New Jersey, Jersey City.	S. W.	Flood.	Scum of sewage on surface of water. Some garbage, wood and paper floating about dock. Some petroleum. No odor noticeable.

The New Jersey shore of the Upper New York Bay was, on the whole, comparatively free from visible traces of sewage except in the neighborhood of the outfalls of local sewers.

Table 20. Results of a sanitary inspection of the Brooklyn shore of New York Bay.

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906. Apr. 5	a. m. 9.10	Fulton Ferry dock.....	N. W.	Ebb...	Scum on surface of water in slip due to sewage. Some wood, garbage, paper and flies.
Apr. 5	9.25	N. Y. Dock Co., Rear of warehouse No. 35.	N. W.	Ebb...	Scum of grease on water; garbage, wood flies. No odor noticeable.
Apr. 5	9.50	N. Y. Dock Co., Rear of warehouse No. 30.	N. W.	Ebb...	Petroleum on surface. Odor plain.
Apr. 5	10.15	N. Y. Dock Co., West side Red D line pier.	N. W.	Ebb...	Large quantity of sewage in water. Water discolored. Scum of grease on surface. Odor 50 ft. to leeward. Paper, rags, wood, straw and garbage. Human feces noted in water.
Apr. 5	10.35	Wall st. ferry, Brooklyn.	N. W.	Ebb...	Some straw and garbage in slips.
Apr. 5	10.55	N. Y. Dock Co., between piers Nos. 13 and 14.	N. W.	Ebb...	Petroleum on surface. Odor plain.
Apr. 5	11.10	Between piers Nos. 16 and 17	N. W.	Ebb...	Large quantity of wood and flies, also garbage, bottles and paper.

Table 20.—(*Continued.*)

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1905.	a. m.				
Apr. 5	11:20	Between piers Nos. 17 and 18.	S.W..	Flood.	Same as between piers Nos. 16 and 17.
Apr. 5	11:35	West side of pier No. 19.	S.W..	Flood.	Scum of sewage on surface. Odor not bad. Wood straw, paper and garbage.
Apr. 5	11:50	Atlantic ave. ferry, Brooklyn.	S.W..	Flood.	Scum of sewage on surface. Wood, straw, papers. Odor carried 40 ft. leeward.
Apr. 5	p. m. 12:15	East side grain elevator, N. Y. Dock Co.	S.W..	Flood.	Scum of sewage on surface. Large quantity of grain refuse in water. Wood and flour, some petroleum.
Apr. 5	1:10	Foot of Amity st.....	S.W..	Flood.	Large quantity of wood. Sewage on surface. Odor 50 ft. leeward; garbage, bottles, grain. In 400 sq. ft. of shore; vegetable matter 2 cu. yds., including wood, animal matter 1-40 cu. yd.
Apr. 5	1:25	Between piers Nos. 35 and 36. Foot Congress st.	S.W..	Flood.	Scum of sewage along dock. Some petroleum.
Apr. 5	1:50	Foot of Baltic st., opposite Governor's Island.	S.W..	Flood.	Sewage in water; water discolored. Scum of grease on surface. Odor 75 ft. leeward. Some wood.
Apr. 5	2:10	Foot Sedgwick st. or street end of slip.	W.....	Flood.	Scum of sewage on surface. Some wood and garbage.
Apr. 5	3:05	At end of pier opposite center of Governor's Island.	W.....	Flood.	No sewage or garbage seen on surface.
Apr. 5	3:35	Foot of DeGraw st.....	W.....	Flood.	Large amount of sewage in water. Water discolored with it. Odor 30 ft. to leeward. Scum of grease on surface.
Apr. 5	3:50	Foot of Hamilton ave., just west of ferry house.	W.....	Flood.	Scum of sewage on surface. Odor of sewage noticeable. Sewer empties here. Wood and paper, dead fish, tin cans and garbage.
Apr. 5	4:20	Hamilton ave. ferry slips.	S.W..	Flood.	Scum of sewage on water. Garbage, wood and paper in water.
Apr. 6	a. m. 9:10	Atlantic basin. Wharf foot Summit st.	N.W..	Ebb...	Large quantity of wood, also garbage, paper and bottles. Scum of sewage on surface.
Apr. 6	9:25	Between piers Nos. 34 and 35 and between pier No. 35 and warehouse.	N.W..	Ebb...	Same as above. Odor of sewage noticeable 40 ft. to leeward.
Apr. 6	9:35	Atlantic basin wharf in rear of bonded warehouses. N. Y. Dock Co.	N.W..	Ebb...	Good deal of driftwood. Some garbage. Scum of sewage on surface in spots. Odor not apparent, except nearby.
Apr. 6	10:00	West side of Atlantic basin.	N.W..	Ebb...	Some wood and garbage. Very little evidence of sewage.
Apr. 6	10:20	Foot of Jewett st.	N.W..	Ebb...	Some wood and garbage in water about docks. No sewage found.
Apr. 6	10:45	Foot of Ithaman st.....	N.W..	Ebb...	Some wood and garbage. Water discolored with sewage to slight extent. Scum of grease on surface.
Apr. 6	11:30	West of pier No. 29....	N.W..	Ebb...	Large quantity of driftwood, also rags, paper and garbage. No sewage seen.
Apr. 6	11:50	Foot of Conover st.....	N.W..	Ebb...	Water discolored with sewage. Scum of grease on surface. No sewer here. Dead dog, wood and garbage on shore. In 400 sq. ft. of shore 1-30 sq. yd. vegetable and 1-30 sq. yd. animal matter.
Apr. 6	p. m. 1:10	Erie Basin, north end, nearest Beard st.	N.W..	Flood.	Scum of sewage on surface. Odor not noticeable. Driftwood.
Apr. 6	1:25	Foot of Richards st., Erie basin.	N.W..	Flood.	Scum of sewage on water. Some wood, garbage, cotton and fibrous material in water.

Table 20.—*Continued.*

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	p. m.				
Apr. 6	2:05	Erie basin, between Richards and Dwight sts.	N. W.	Flood	Large quantity of machine oil on surface of water from machine shops nearby. Sawdust and many small dead fish floating on surface of water.
Apr. 6	2:15	South end of Erie basin	N. W.	Flood	Good deal of driftwood on surface of water. No sewage.
Apr. 9	a. m. 9:25	Wharf between Erie basin and Gowanus bay.	N.	Ebb	Scum of sewage on surface of water on both sides of wharf. Some garbage and wood. No odor.
Apr. 9	9:30	Brooklyn basin, near entrance to Gowanus bay.	N.	Ebb	Scum of sewage on surface; wood and garbage. No odor.
Apr. 9	10:20	Inner shore of Brooklyn basin.	N.	Ebb	Scum of sewage on surface; wood and garbage. No odor.
Apr. 10	9:18	Off Gowanus bay on course of 39th st. ferry.	S. W.	Ebb	Scum of sewage on water. Some driftwood and garbage.
Apr. 10	9:25	Ferry slip, foot 39th st., Brooklyn.	W.	Ebb	Scum of sewage on water. No odor.
Apr. 10	9:30	Foot of 42nd street	W.	Ebb	Scum of sewage on water. Straw, paper, rags, garbage and feces. Water discolored with sewage. No odor.
Apr. 10	10:05	Foot 43d st.	W.	Ebb	Same as at 42nd st.
Apr. 10	10:20	Between piers Nos. 4 and 5. Bush docks. Between pier 2 and 4.	S. W.	Ebb	Scum of sewage. Salmon cans and wrappers in water.
Apr. 10	10:30	West of Bush docks. Shore foot 51st st.	S. W.	Ebb	Large quantity of sewage—scum on surface. Water discolored. Odor 50 ft. to leeward. In 600 sq. ft. of shore ½ cu. yd. vegetable matter.
Apr. 10	11:10	Shore between 53rd and 54th st., Brooklyn.	S.	Ebb	Scum of sewage on water; garbage and wood. In 600 sq. ft. of shore ½ cu. yd. vegetable matter.
Apr. 10	11:25	Morse Dry Dock Co., foot 56th st.	S.	Ebb	Scum of sewage on surface, about docks. Driftwood. No odor.
Apr. 10	11:35 a. m.	Foot 57th st.	S.	Ebb	Same as at 56th st.
Apr. 10	12:15	Shore just west of 57th st.	S. E.	Ebb	Scum of sewage. Odor 50 ft. to leeward. In 600 sq. ft. of shore ½ cu. yd. vegetable matter.
Apr. 10	1:10	Foot of 65th st.	S. E.	Ebb	Large sewer running out to pierhead line, under wharf. The sewage sets back toward south, toward Edison Co.'s plant. Water discolored for several hundred yards with sewage. Scum on surface. Odor not bad. Small grease balls on surface of water, the size of marbles.
Apr. 10	1:50	Along shore road of Bay Ridge.	S. E.	Ebb	Small sewers. Scum of sewage on water. No odor.
Apr. 10	2:20	Dock foot 69th st.	S. E.	Flood	Scum of sewage both sides of dock. No odor.
Apr. 10	2:30	South shore of dock.	S. E.	Flood	Water discolored with sewage—scum on surface. Small grease balls. Odor 50 ft. to leeward. Several sewers here run out to beyond low water mark.
Apr. 10	2:50	Foot 71st., Bay Ridge.	S. E.	Flood	Large brick sewer. Water discolored with sewage in 100 yds. radius. Scum grease on surface. Sewage sets toward Narrows (south).
Apr. 10	3:30	71st to 79th st., along shore.	S. E.	Flood	Scum of sewage on surface. Several small sewers. Some driftwood.
Apr. 10	4:10	Foot 79th st.	S. E.	Flood	Sewer, similar to 65th st. sewer, covered, out to pierhead line. Sewage sets toward Narrows (south). Water discolored for several hundred yards. Odor not bad.

Table 20.—*Concluded.*

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1905.	a. m.				
Apr. 11	9:35	Shore between 79th st., Bay Ridge and Crescent Athletic Club.	N. E.	Ebb...	Scum of sewage on surface. Some driftwood. No odor.
Apr. 11	9:50	Back of Crescent Club House.	N. E.	Ebb...	Two sewers. Scum of grease on surface. Driftwood, bottles, tin cans. Sewer at high water mark. Odor 20 ft. to leeward. In 400 sq. ft. of shore 1 cu. yd. vegetable matter.
Apr. 11	10:15	100 yards south Crescent Club.	N. E.	Ebb...	Small sewer out to pierhead line. Scum of grease on surface. Some wood and garbage.
Apr. 11	10:25	Shore on to 88th st.....	N. E.	Ebb...	Less sewage. Considerable wood.
Apr. 11	10:30	Side of private dock south of 88 th st.	N. E.	Ebb...	More sewage. Wood and paper in water.
Apr. 11	11:15	Foot 92nd st.....	N. E.	Ebb...	Big sewer covered out to pierhead line. Scum of sewage both sides pier. Water slightly discolored. Odor not strong. Grand deal of wood nearby.
Apr. 11	11:25	Shore between 92nd st. and low flats south.	N. E.	Ebb...	Fairly free from sewage. Some wood.
Apr. 11	11:25	Off flats (old dock)	N. E.	Ebb...	Hardly any sewage. Two small sewers.
Apr. 11	11:45	Just south of flats.....	N. E.	Ebb...	Water discolored and scum of sewage on surface.
Apr. 11	11:50	Foot 3rd ave.....	N. E.	Ebb...	Seaweed piled up in corner of shore 3 ft. high.
Apr. 11	p. m. 12:00	Foot 4th ave., north of dock.	N. E.	Ebb...	Good deal of sewage. Grease ball 2 in. x 2 in. Garbage and wood. No odor. In 400 sq. ft. of shore 4 cu. yd. vegetable and 1-10 cu. yd. animal matter.
Apr. 11	12:25	Between 4th ave. and Fort Hamilton.	N. W.	Ebb...	Shore free from sewage.

The eastern, or Brooklyn, shore of Upper New York Bay was, for nearly its whole length, obviously polluted with sewage, refuse and garbage. The amount of this pollution diminished in the direction of the Narrows.

Table 21. Results of a sanitary inspection of the shore of the islands in the Upper Bay.

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1905.	a. m.				
Apr. 7	9:10	Governor's Island, immediately west of ferry dock.	N. W.	Ebb...	Sewage in water. Formed feces. No odor. Some wood and fiber. Mattress.
Apr. 7	9:25	Governor's Island, 150 yds. west on north shore.	N. W.	Ebb...	Two sewers. Scum of sewage on surface. Sewage in water. Feces and tissue paper. Horse droppings. Little driftwood. No odor.
Apr. 11	9:45	Governor's Island, 200 yds. west of ferry dock.	N. W.	Ebb...	Sewer. Odor 50 ft. to leeward. Some scum of sewage on surface.

Table 21.—(*Concluded.*)

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	a. m.				
Apr. 7	10:10	Governor's Island, near wharf on north shore.	N. W..	Ebb...	Water discolored with sewage. Scum of grease on surface. Toilet paper, feces. Odor 50 ft. to leeward. Sewer near. Sewage from this sewer.
Apr. 7	10:25	Governor's Island, west side Castle Williams.	N. W..	Ebb...	Water discolored with sewage. Scum of grease on surface. Toilet paper and feces. Odor 20 ft. to leeward. No garbage or wood.
Apr. 7	10:50	Governor's Island, along bulkhead on west shore to retain filling.	N. W..	Ebb...	Large quantity of floating wood, garbage and straw. Scum of sewage on surface, also feces. Some odor. Sewage seemed to come from distance. No sewers near. Current from Brooklyn shore.
Apr. 7	11:10	Governor's Island inlet where filling is being done	W	Ebb...	Scum of grease on surface of water.
Ap. 7.	11:25	Governor's Island inlet, near dredges.	W....	Ebb...	No sewage noticed in mud pumped from Buttermilk channel. No odor.
Apr. 7	11:50	Governor's Island, along bulkhead on south shore.	W....	Ebb...	Some sewage near small sewer at beginning of wall. Very little wood and garbage.
	p. m.				
Apr. 7	12:20	Governor's Island, east shore.	W....	Ebb...	Water discolored with sewage for 200 yds. from nearby sewers. Toilet paper and feces.
Apr. 7	12:30	Governor's Island, cable crossing.	W....	Ebb...	Sewage from sewer here.
Apr. 7	1:20	Ellis Island, ferry slip...	W....	Flood.	Scum of sewage on surface. Some garbage and paper in water. Water discolored with sewage at one point.
Apr. 7	1:35	Ellis Island. New Hospital wharf, south side	W....	Flood.	Some wood and garbage. New wharf being made by dumping between here and Liberty Island. Men seemed to be careful in trimming.
Apr. 7	1:45	Ellis Island, southwest extremity.	W....	Flood.	Slight scum of sewage on surface.
Apr. 7	2:00	Ellis Island, west shore opposite Black Tom.	W....	Flood.	Sewer near. Water discolored with sewage. Scum of grease on surface. Shore and water covered with paper, rags, wood, tin cans, garbage. Great quantity of garbage. In 400 sq. ft. shore 1-10 cu. yd. vegetable and 1-40 cu. yd. animal matter.
Apr. 7	2:10	Ellis Island, off coal dock	W....	Flood.	Scum of sewage on surface.
Apr. 7	2:15	Ellis Island, north shore opposite Lehigh Valley freight station, Communipaw.	W....	Flood.	Scum of sewage from nearby sewers. No odor. Feces in water.
Apr. 7	2:25	Ellis Island, east shore, opposite Manhattan.	W....	Flood.	No garbage or sewage along docks.
Apr. 7	3:20	Liberty Island, north side toward Ellis Island.	W....	Flood.	Water muddy from wind. Could not detect sewage. Bones on shore. Two or three small sewers. No odor.
Apr. 7	3:35	Liberty Island, west shore, opposite National docks.	W....	Flood.	Scum of sewage on surface, straw and driftwood. No sewers on this shore. Water not discolored with sewage. No odor.
Apr. 7	3:50	Liberty Island, south shore Liberty Island, opposite Staten Island.	W....	Flood.	Considerable sewage in water. Scum of grease on surface all along shore. Only one small sewer on this shore. The sewage comes from a distance. No odor. Water somewhat discolored with sewage. Some straw on water.
Apr. 7	4:20	Liberty Island, east shore Liberty Island, near boat landing.	W....	Flood.	Slight scum of sewage on surface. Considerable wood. Some garbage in the water.

The shores of the islands of the Upper Bay were, for the most part, comparatively clean, except for sewage which was evidently discharged from buildings on the islands themselves. There were points, however, on Governor's Island and Liberty Island where remains of sewage were found which could not have originated nearby. This was long range pollution of the most objectionable character.

Table 22. Results of a sanitary inspection of the shores of New York Bay from the Narrows to Coney Island and Sheepshead bay.

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	p. m.				
Apr. 11	1:10	Shore at north end of Fort Hamilton.	N. W..	Ebb...	Slight scum of sewage near dock. Shore fairly clean.
Apr. 11	1:20	Shore between the two docks.	N. W..	Ebb...	Shore along wall fairly free from sewage. Some wood.
Apr. 11	1:40	Just north of coal dock..	N. W..	Ebb...	Large sewer at high water mark. Water discolored. Scum on surface. Odor 30 ft. to leeward.
Apr. 11	2:05	South of dock.....	N. W..	Ebb...	Goood deal of driftwood. Very little sewage.
Apr. 11	2:35	South end of Fort Hamilton.	N. W..	Flood.	Seaweed, garbage and wood. No sewage.
Apr. 11	3:10	Shore between Fort Hamilton and first dock, foot 9th st., Bath Beach.	N. W..	Flood.	Free from sewage, except at opening of sewer 400 yds. south of Fort Hamilton. Some seaweed, garbage and driftwood. In 400 sq. ft. of shore 1-20 cu. yd. vegetable matter.
Apr. 11	4:15	Dock at foot of Bay, 9th st., Bath Beach.	N. W..	Flood.	Sewer under dock out to pierhead line. Some scum of sewage on surface. No odor.
	a. m.				
Apr. 12	10:00	Foot Bay 13th st., Bath Beach.	N. W..	Flood.	Shore clean. No sewage visible in water.
Apr. 12	10:20	Foot Bay 15th st.....	N. W..	Ebb...	Same. Some wood.
Apr. 12	10:35	Foot Bay 17th st.....	N. W..	Ebb...	Sewer here. Scum of sewage on water. Odor 50 ft. to leeward. Driftwood and garbage. In 400 sq. ft. of shore 1 cu. yd. animal matter.
Apr. 12	10:50	Foot Bay 19th st.....	N. W..	Ebb...	Shore clean. No sewage.
Apr. 12	11:15	Foot Bay 25nd st.....	N. W..	Ebb...	Shore clean. No sewage.
Apr. 12	11:25	Foot Bay 23rd st.....	N. W.	Ebb...	No sewage. Some straw and wood.
Apr. 12	11:40	Foot 21st ave., Bensonhurst.	N. W..	Ebb...	Some driftwood and garbage. No sewage.
Apr. 12	11:55	Foot Bay 32nd st., Bensonhurst.	N. W.	Ebb...	No sewage. Some wood.
	p. m.				
Apr. 12	12:15	Foot Bay 36th st.....	N. W..	Ebb...	No sewage. Some wood.
Apr. 12	1:10	Shore of bathing pavilion, Ulmer Park.	N. W..	Ebb...	Scum of sewage on surface of water, in spots. Wood, rags, paper, and garbage on shore. In 400 sq. ft. of shore ¼ cu. yd. vegetable matter.
Apr. 12	1:40	Off Marine Basin Co. dock.	N. W..	Ebb...	No sewage in water at end of docks. On Gravesend bay side slight scum of grease in places.

Table 22.—(*Continued.*)

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	p. m.				
Apr. 12	2:05	East shore of Gravesend bay, south of marine dock.	N. W..	Ebb...	Seaweed, straw and wood. No sewage visible.
Apr 12	2.35	East shore Gravesend bay. Back of fishing docks.	N. W..	Ebb...	Seaweed, straw and wood. No sewage visible.
Apr. 12	3:10	Same shore near Coney Island creek outlet...	N. W..	Ebb...	Slight scum on surface from waters of creek. No odor.
Apr. 12	3:50	Same shore, along flats near Coney Island.	N. W..	Ebb...	No sewage. Some seaweed.
Apr. 12	4:20	Bridge over Coney Island creek.	N. W..	Ebb...	Several sewers empty into creek between bridge and Gravesend bay. Scum of sewage on surface of creek. No odor.
	a. m.				
Apr. 13	10:05	South shore of Gravesend bay from Coney Island creek to Sea Gate.	N. W..	Flood.	Scum of sewage on surface; feces, house sweepings and toilet paper on water. About 12 sewers along this shore, one at foot of each street. Odor not bad.
Apr. 13	10:55	Southwest shore of Gravesend bay.	N. W..	Flood.	Good deal of driftwood on shore. Scum of sewage on water. In 400 sq. ft. of shore ½ cu. yd. vegetable matter.
Apr 13	11:25	Shore of Gravesend bay, around east side of Norton's Point.	S....	Ebb...	Great quantity of driftwood and some garbage on shore. Scum of sewage on surface of water. Grease balls 3 in. x 3 in. No sewers nearby. Driftwood and sewage backs in from New York bay with the tide. (Men gathering wood on shore, said new supply came in every day.) In 400 sq. ft. of shore 3 cu. yds. vegetable matter, mostly wood, 1-20 cu. yd. animal matter.
Apr. 13	11:50	Shore off Norton's Point to Atlantic Yacht Club House at end of Gravesend bay.	S.....	Ebb...	Scum of sewage on surface. Two grease balls, 2 x 2 and 3 x 3 inches. No odor of sewage. Some garbage and driftwood on water.
	p. m.				
Apr. 13	12:25	Shore of New York bay, Sea Gate west of Norton's Point.	S.....	Ebb...	Immense quantity of driftwood. In 400 sq. ft. of shore, 5 cu. yds. Some garbage, straw and bottles. No sewage on water. Grease ball on shore 2 x 2 in.
Apr. 13	1:20	Shore off Sea Gate to Coney Island light.	S. E...	Ebb...	Great quantity of driftwood. Some garbage. No sewage detected.
Apr. 13	2:15	South shore Sea Gate from light to Seabourne hotel.	S. E...	Ebb...	Some driftwood where shore runs back some distance. Some seaweed. Very little garbage. No evidence of sewage.
Apr. 13	3:10	Seabourne Hotel to Sea Gate Beach Hotel	S. E...	Ebb...	Not much driftwood. Some straw on shore and seaweed No sewage.
Apr. 13	3:55	Sea Gate Beach hotel to Steeplechase Park, Coney Island.	S. E...	Ebb...	Not much driftwood or garbage. Considerable amount of straw and seaweed. No sewage.
Apr. 13	4:20	Off Steeplechase Park...	S. E...	Ebb...	Shore very clean all along here.
Apr. 14	9:30	Coney Island shore from Steeplechase Park to Dreamland.	S. E...	Flood.	Shore quite clean Some seaweed and driftwood. No remains of sewage visible.
Apr. 14	9:55	Shore of Dreamland....	S. E...	Flood.	Some seaweed.
Apr. 14	10:25	Beach from Dreamland to iron pier.	S. E...	Flood.	Small quantity of seaweed. No garbage or sewage.
Apr. 14	10:50	Palmer's bathing beach.	S. E...	Flood.	Beach clean.
Apr. 14	11:15	Municipal shore east of Palmer's.	S. E...	Flood.	Some seaweed.
Apr. 14	11:45	Parkway baths, south..	S. E...	Flood.	Large quantity of seaweed on shore. In 400 sq. ft. of shore 2 cu. yds. of seaweed.
	p. m.				
Apr. 14	12:20	Between Parkway baths and Brighton Beach hotel.	S. E...	Ebb...	Large quantity seaweed, 4 cu. yds. in 400 sq. ft. of shore. Dead dog.

Table 22.—(*Concluded.*)

Date.	Time.	Place.	Wind.	Tide.	Condition of shore.
1906.	*p. m.*				
Apr. 14	1:15	Shore just east of Brighton Beach hotel.	S. E...	Ebb...	Immense quantity seaweed. Six cu. yds. in 400 sq. ft. of shore. Some driftwood. Small quantity garbage.
Apr. 14	1:50	Shore front of Manhattan Beach hotel.	S. E...	Ebb...	Some seaweed along seawall.
Apr. 14	2:20	From Manhattan Beach hotel to Oriental.	S. E...	Ebb...	Seaweed on water along seawall.
Apr. 14	2:45	Front of Oriental hotel..	S. E...	Ebb...	Seaweed along seawall.
	a. m.				
Apr. 16	9:20	Sheepshead bay foot of shore road.	N.....	Flood.	Scum of sewage on surface near shore. Small amount of garbage and seaweed. No odor.
Apr. 16	9:50	Shore road to Ocean ave.	N.....	Flood.	No sewage noticed.
Apr. 16	10:25	Ocean ave. to foot East 23rd st.	N. W..	Flood.	Some seaweed. No sewage.
Apr. 16	10:45	East 23rd st. to East 27th st.	N. W..	Flood.	Shore quite clean.
Apr. 16	11:35	Foot 27th st. to end of Emmons ave., extreme east end Sheepshead bay.	N. W..	Flood.	Some seaweed. No sewage found along shore.
Apr. 16	1:10	Pumping station east end of town.	N.....	Flood.	Water in Sheepshead bay stirred up by dredger, filling in flats between bay and Manhattan Beach. Very little sewage detected in bay. Only slight scum at certain points. No odor. Sewage of Sheepshead Bay (town) is pumped to eastern extremity of town, east of race track, mixed with chlorinated lime, the liquid part discharged into Bull's Creek and the solid siphoned out onto the flats nearby. There was no odor where deodorized contents of deposit tanks were discharged April 14. There are oyster beds in Bull's Creek where liquid part of sewage empties.
Apr. 16	2:35	[South shore of Sheepshead bay from Coney Island creek to bridge.	N.....	Ebb...	Shore clean. Scum of sewage at one point near opening of creek.
Apr. 16	3:15	South shore from bridge to Oriental hotel.	N. W..	Ebb...	No sewage on water. Shore clean.
Apr. 16	3:55	Point east of Oriental hotel.	N. W..	Ebb...	Sewage from Manhattan Beach and Oriental hotels pumped to pumping station here, and after treatment with lime, emptied into New York bay, just outside of seawall.

On comparing table 22 with 18 it will be seen that both shores of the Lower Bay were polluted for a considerable distance from the Narrows. The Staten Island shore contained large quantities of garbage as far as the inspections were continued in that direction, that is, Midland Beach. The north shore of the Lower Bay was
fairly free from visible evidences of sewage and other pollu-
44 tion, except near the outlets of local sewers, where occasionally small amounts of sewage scum were seen floating at a considerable distance from the shore.

The presence in this vicinity of large grease balls which could only have been derived from sewers of considerable length, showed that some sewage was evidently transported to these shores from Brooklyn sewers which emptied into the Upper Bay.

That portion of the shore of the outer harbor which lies in the vicinity of Norton's Point contained so much driftwood, garbage and sewage matter that it seems reasonable to conclude that this point is a collecting center for refuse which flows out of the Narrows. As much as 5 cubic yards of animal and vegetable refuse were found on 400 square feet of beach in this vicinity. Men who were found gathering wood here said that the supply of fuel was inexhaustible.

From Norton's Point eastward there was a constantly diminishing amount of putrescible refuse until, about midway between the two ends of Coney Island, it was reduced to an occasional lot of garbage or a dead animal or so. The shores and water of Sheepshead Bay were fairly clean, as might be expected at this season of year.

Inspections confirmed what the chemical and bacteriological analyses of the commission had already shown concerning the objectionable practice of cultivating oysters in the creeks in the immediate vicinity of New York.

Bodine creek, on Staten Island, where large quantities of oysters are "drinked" in preparation for market was reported by the inspector to be obviously polluted with sewage. The shores were strewn with vegetable and animal matters and a scum of grease and
petroleum was on the water.

45 Equally objectionable conditions connected with the oyster industry were found elsewhere. The liquid part of the sewage of the town of Sheepshead Bay was found to be emptied, after being treated with chemicals, into Bull's creek in the immediate proximity of oyster beds.

The danger of polluting oysters in these ways was clearly pointed out in the first report of the New York Bay Pollution Commission. The existence of the resulting danger to the public health was em-

phasized by a typhoid oyster outbreak which occurred at Lawrence, N. Y., in 1904, and was investigated and reported on by me.

D—Conclusions.

The principal conclusions which it seems proper to draw from the foregoing investigations are in conformity with the conclusions recorded in the first report of the commission. They are as follows:

1. The waters of the bay and adjacent waters are unmistakably, but not as yet badly, polluted.

2. The sewage is not uniformly dispersed and diffused throughout the depth and breadth of the tidal currents. The discharge of crude sewage results in polluting the water more at the surface than in the depths below.

3. The discharge of sewage along the shores often leads to the production of a decided local nuisance.

4. Although the present method of disposing of the sewage of Manhattan is, perhaps, as acceptable as any method of emptying crude sewage into these waters could be, it is far from being always satisfactory.

5. The disposal of sewage at the pierhead line, as practiced on Manhattan Island is much to be preferred to the plan of
46 emptying it at the bulkhead line as is generally practiced elsewhere in this vicinity.

6. There is no doubt but that offensive matters from the sewage, and the sewage itself, are sometimes transported long distances by the tides and winds and deposited on shores remote from any sewer outlet.

7. Excepting in such heavily polluted waters as Gowanus Canal, there is probably always enough oxygen in the water to enable the bacteria of decomposition to carry on their work without the production of offensive odors.

8. No other method of disposing of the sewage of New York and vicinity is suggested as the result of these investigations. It is evident that some other method should be devised, if practicable, but the satisfactory study of this question involves investigations of a far more exhaustive character and of a wider scope than have thus far been possible.

47 I, George R. Van Namee, Clerk of the Assembly, do hereby certify that the aforegoing is a true and correct copy of Assembly Document No. 76 as filed at this office, being a Report of the New York Bay Pollution Commission of May 3rd, 1903, and of the whole thereof.

[Seal Clerk of Assembly, State of New York.]

GEORGE R. VAN NAMEE,
Clerk of the Assembly.

Dated at Albany, N. Y., this 30th day of September, 1913.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 4.

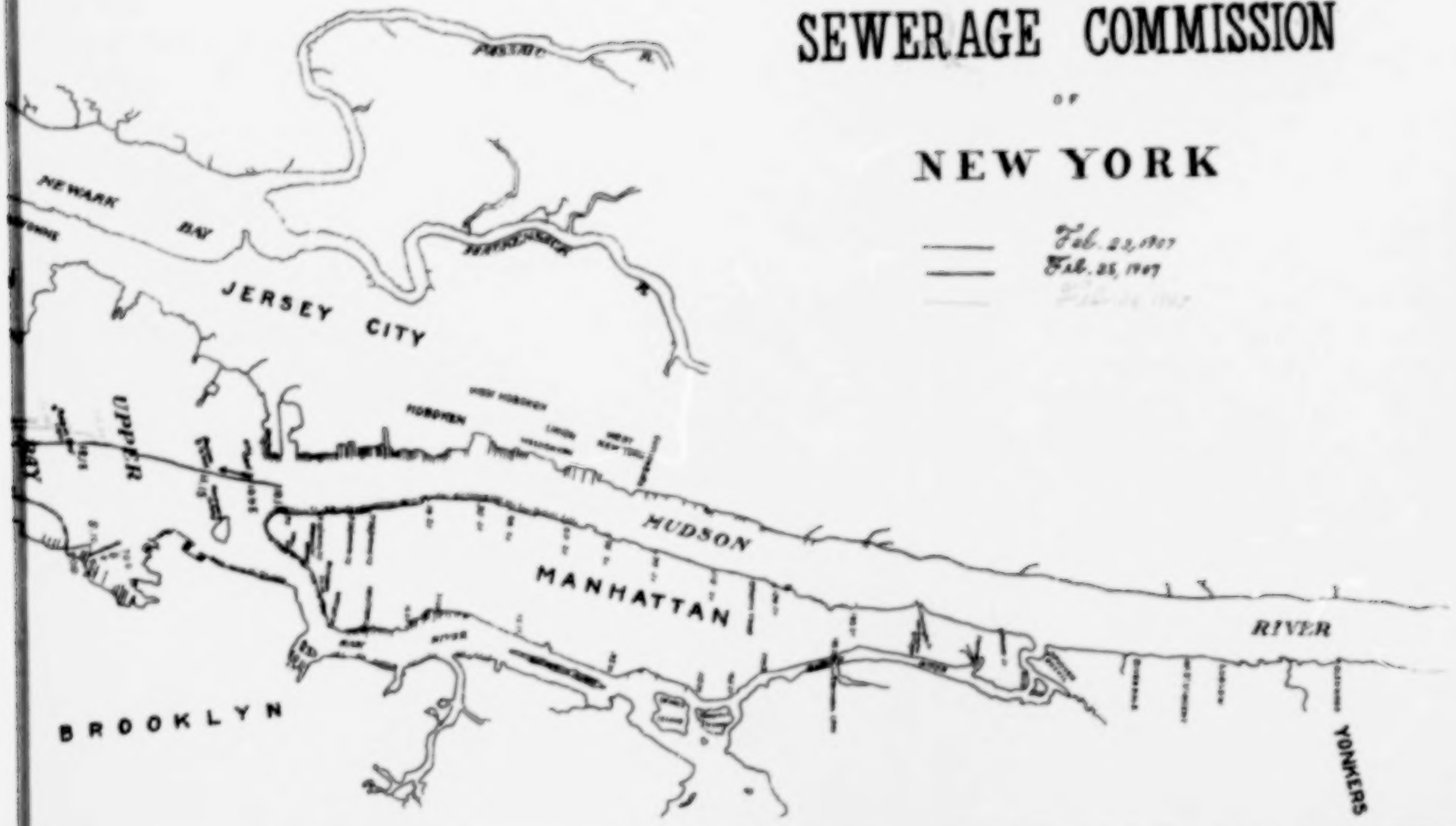
JAMES D. MAHER,
Commissioner.

1
SOUTH AMBOY
PERTH AMBOY
RICHMOND
NEWARK BAY
BAYONNE
JERSEY CITY
HOBOKEN
UPPER BAY
LOWER BAY
CONEY ISLAND
BROOKLYN
SANDY HOOK

Complainant's Exhibit No. 14.
James D. Maher
Commissioner

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK

Feb. 22, 1907
Feb. 25, 1907



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 5.

JAMES D. MAHER,
Commissioner.

2
SOUTH AMBOY
PERTH AMBOY
KEYPORT
RICHMOND
NEWARK BAY
BAYONNE
JERSEY CITY
HOBOKEN
UPPER BAY
LOWER BAY
SANDY HOOK
CONEY ISLAND
BROOKLYN

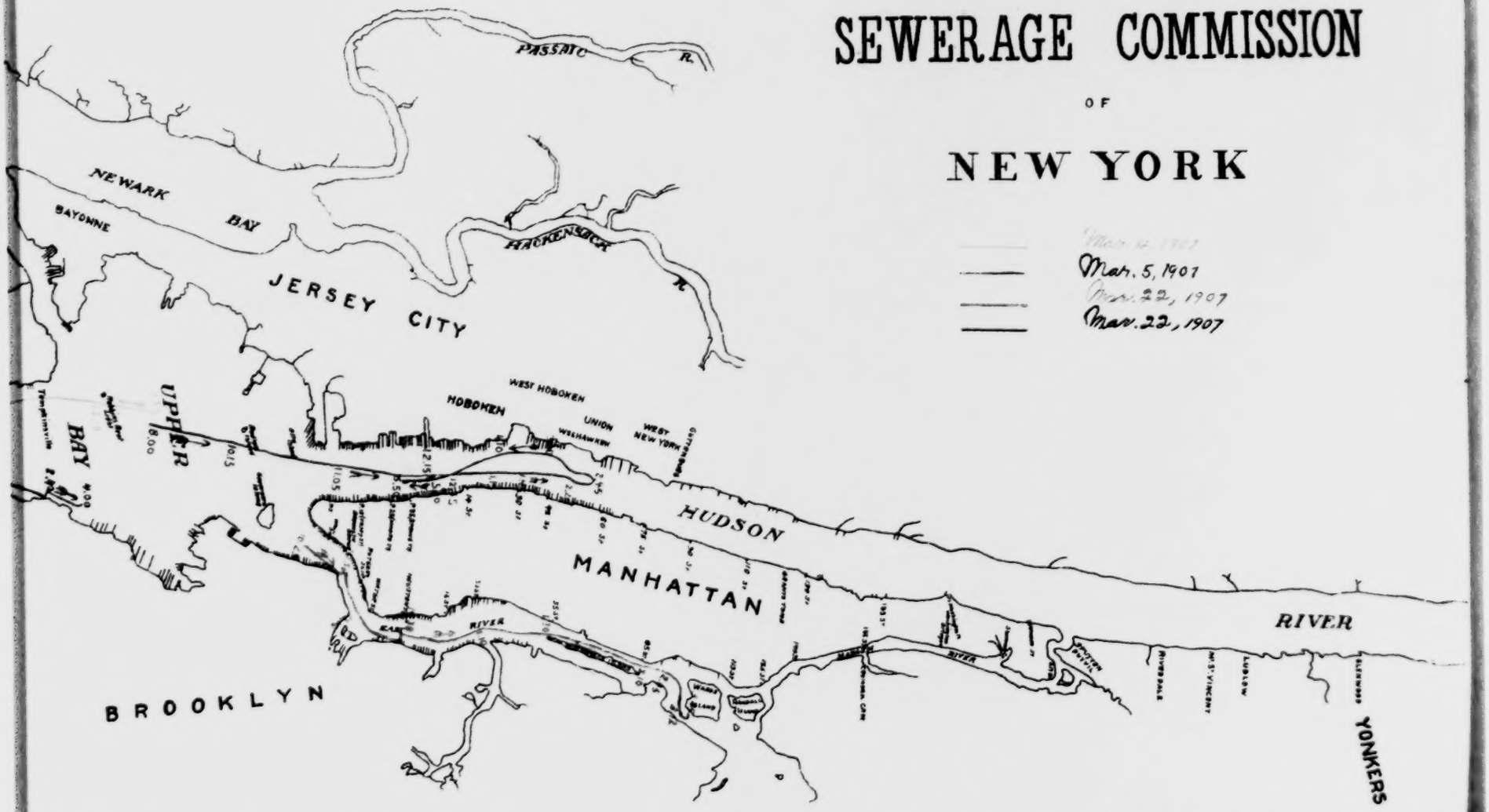
Complainant's Exhibit No. 1.
James Dimock
Commissioner

METROPOLITAN SEWERAGE COMMISSION

OF

NEW YORK

Mar. 5, 1907
Mar. 22, 1907
Mar. 22, 1907



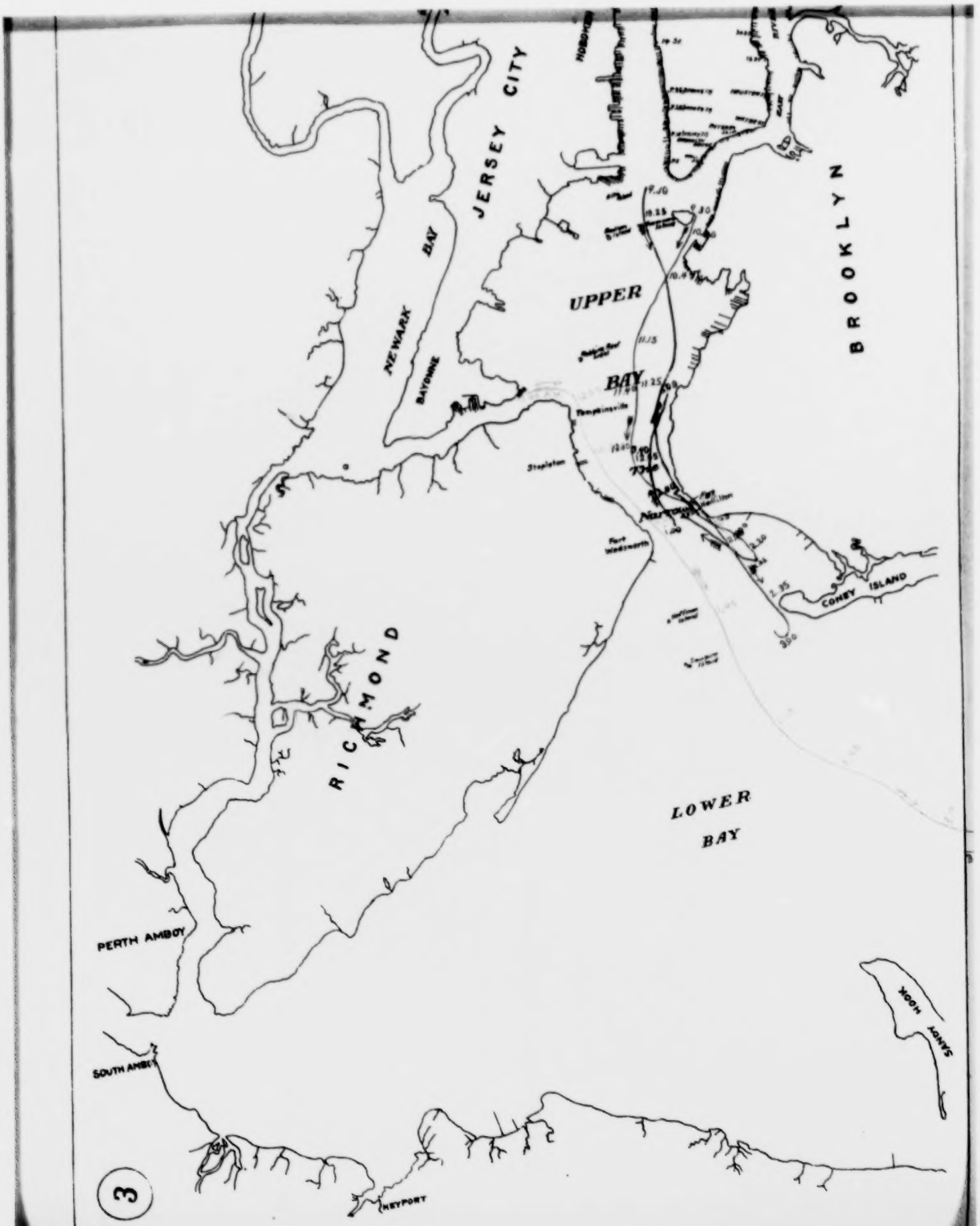
THE PEOPLE OF THE STATE OF NEW YORK.
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 6.

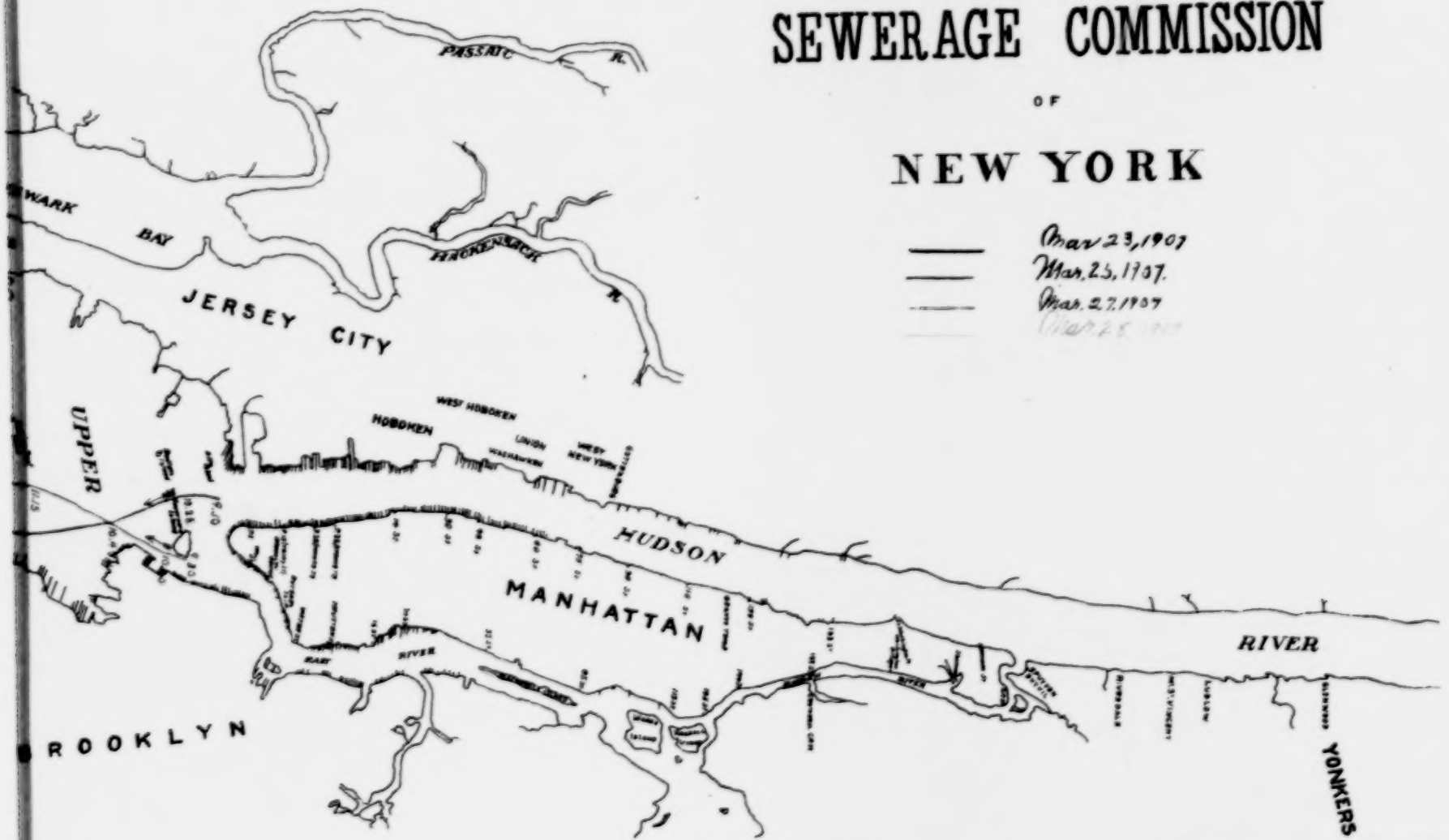
JAMES D. MAHER,
Commissioner.


JERSEY CITY
NEWARK BAY
BAYONNE
UPPER
BAY
BROOKLYN
CONEY ISLAND
RICHMOND
LOWER
BAY
PERTH AMBOY
SOUTH AMBOY
SANDY HOOK
KEYPORT
3

Complainant's Exhibit No. 6.
James D. Maher,
Commissioner

METROPOLITAN
SEWERAGE COMMISSION
OF
NEW YORK

Mar 23, 1907
Mar. 25, 1907.
Mar. 27, 1907



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 7.

JAMES D. MAHER,
Commissioner.

4
SOUTH AMBOY
PERTH AMBOY
RICHMOND
NEWARK
BAY
BAYONNE
JERSEY CITY
HOBOKEN
UPPER
BAY
LOWER
BAY
CONEY ISLAND
BROOKLYN

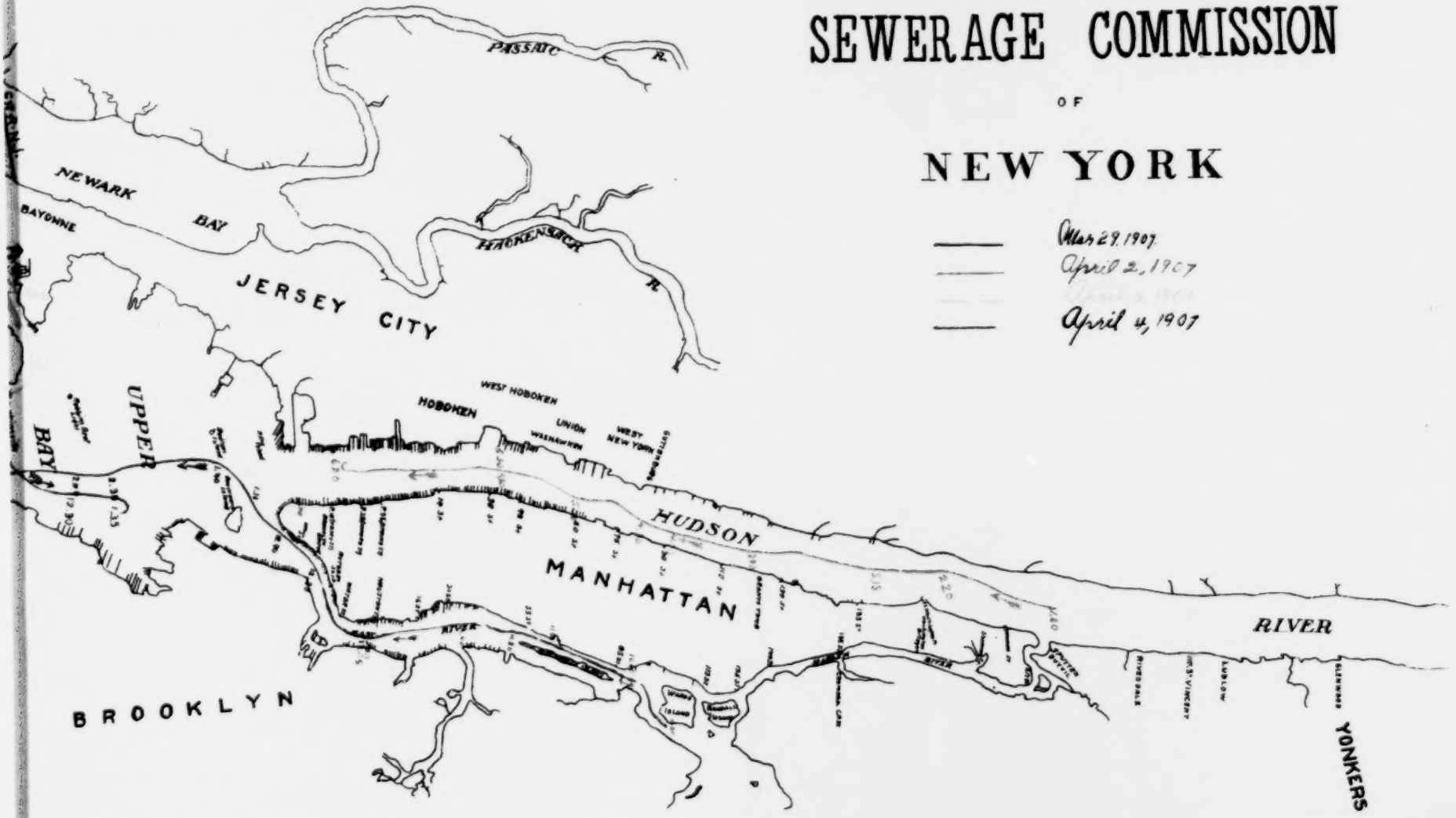
Complainant's Exhibit No. 7.
James D. Maher,
Commissioner.

METROPOLITAN SEWERAGE COMMISSION

OF

NEW YORK

— May 29, 1907.
— April 2, 1907.
— April 4, 1907.



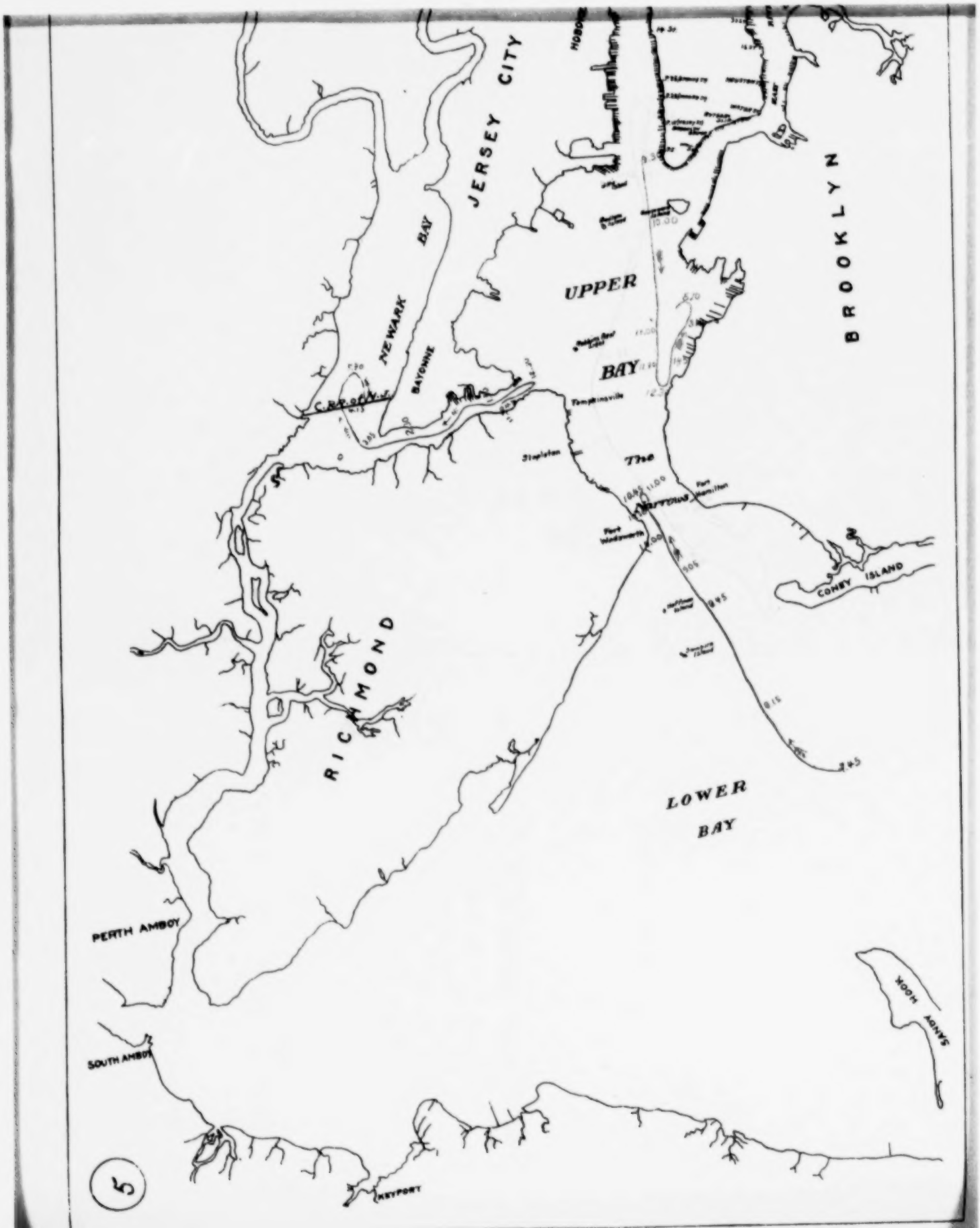
THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 8.

JAMES D. MAHER,
Commissioner.


JERSEY CITY
NEWARK BAY
BAYONNE
UPPER BAY
BROOKLYN
CONEY ISLAND
RICHMOND
LOWER BAY
PERTH AMBOY
SOUTH AMBOY
SANDY HOOK
KEYPORT
5

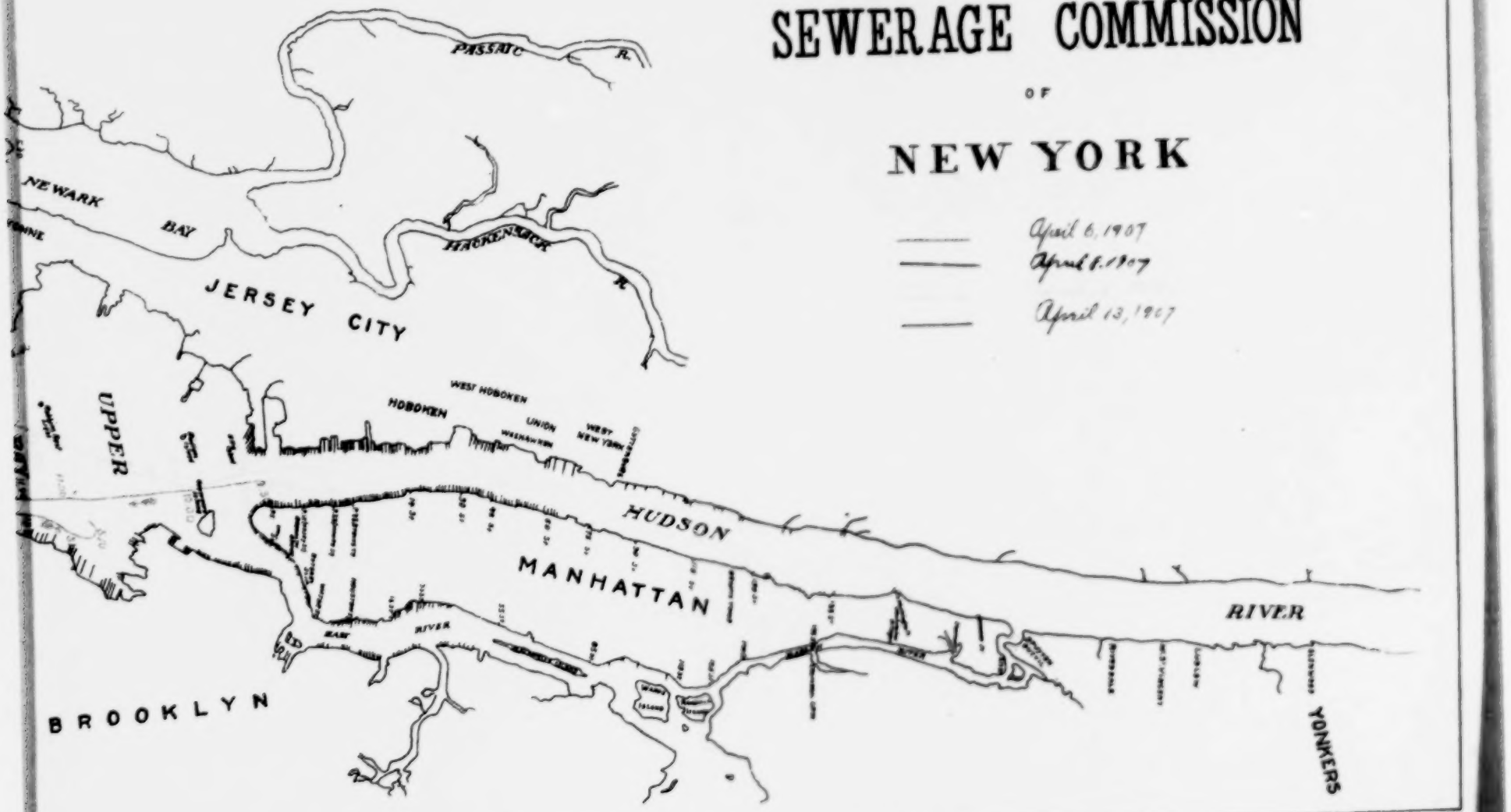
Complainant's Exhibit No. 8.
James A. Mabie,
Commissioner

METROPOLITAN SEWERAGE COMMISSION

OF

NEW YORK

April 6, 1907
April 8, 1907
April 13, 1907



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 9.

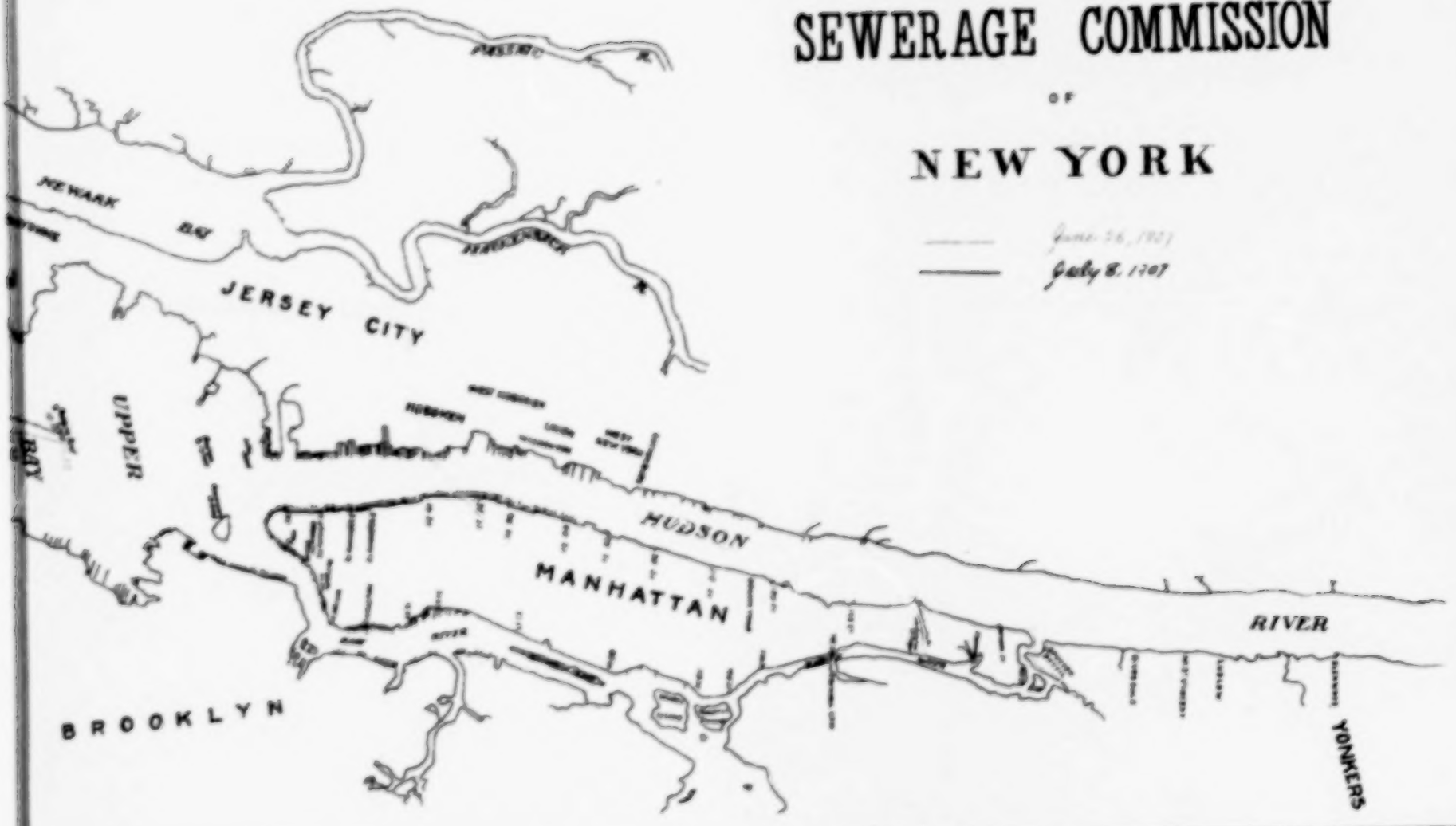
JAMES D. MAHER,
Commissioner.

6
RICHMOND
NEWARK
BAY
JERSEY CITY
UPPER
BAY
LOWER
BAY
BROOKLYN

Complainant's Exhibit No. 9.
James D. Maher
Commissioner

METROPOLITAN SEWERAGE COMMISSION OF NEW YORK

June 26, 1907
July 8, 1907



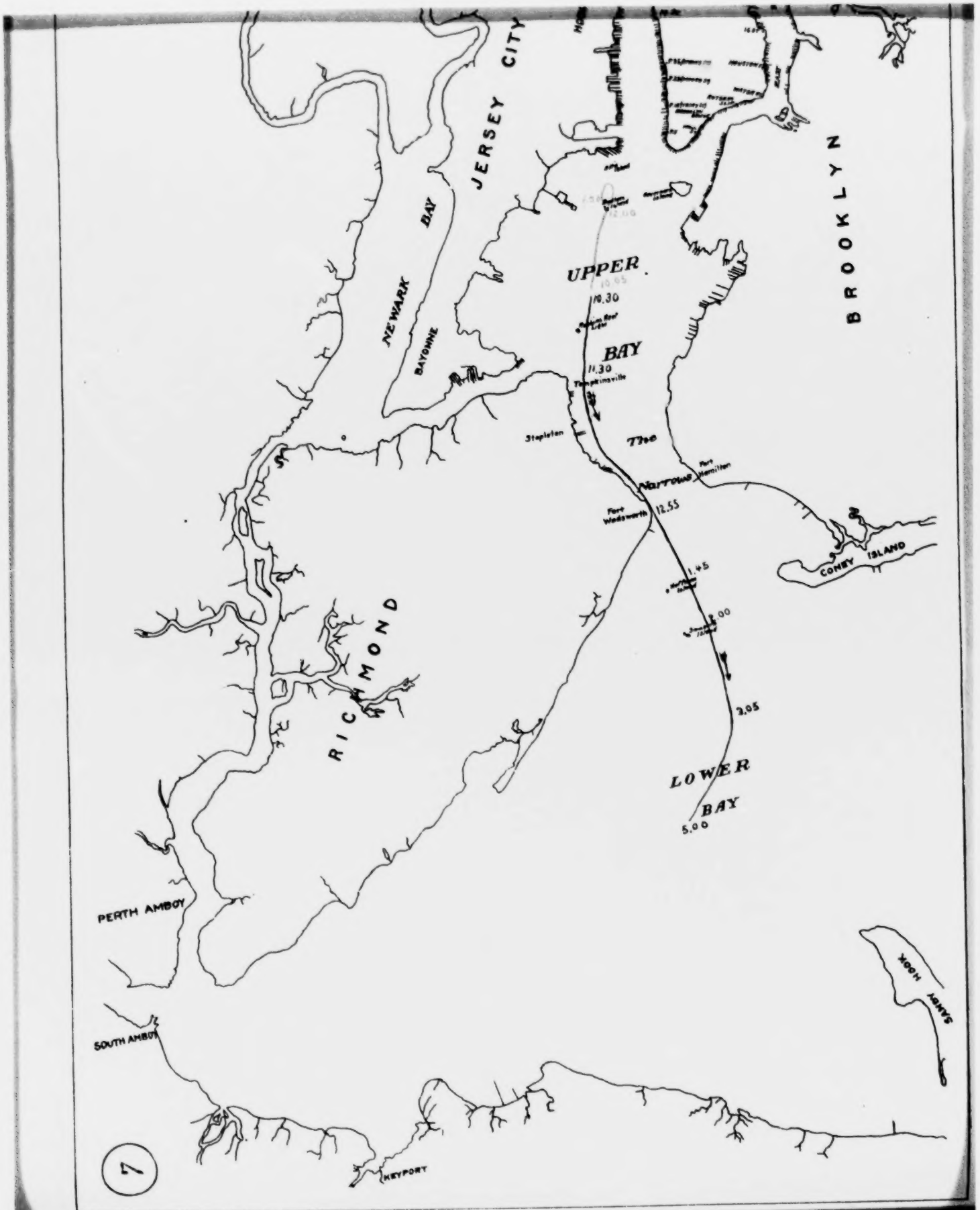
THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 10.

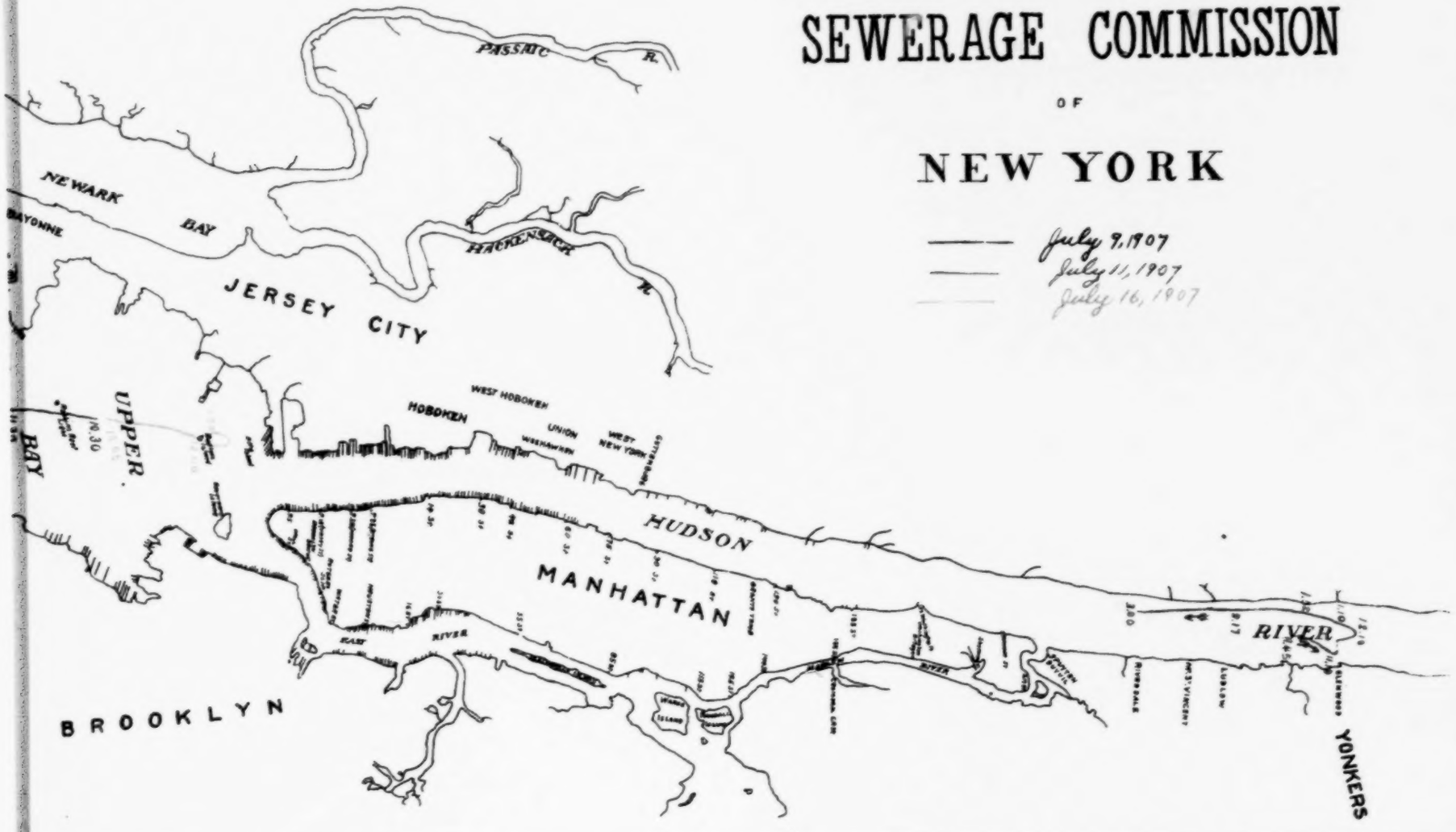
JAMES D. MAHER,
Commissioner.


JERSEY CITY
NEWARK BAY
BAYONNE
BROOKLYN
UPPER
BAY
10.30
11.30
Stapleton
7?ee
Narrows
Fort Hamilton
Fort Wadsworth
12.55
CONEY ISLAND
1.45
2.00
2.05
LOWER
BAY
5.00
RICHMOND
PERTH AMBOY
SOUTH AMBOY
SANDY HOOK
KEYPORT
7

Complainant's Exhibit No. 10.
James A. Maher
Commissioner.

METROPOLITAN
SEWERAGE COMMISSION
OF
NEW YORK

July 9, 1907
July 11, 1907
July 16, 1907



THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 11.

JAMES D. MAHER,
Commissioner.


JERSEY CITY
NEWARK BAY
BAYONNE
UPPER
BAY
BROOKLYN
Stapleton
Narrows
Fort Wadsworth
CONEY ISLAND
RICHMOND
LOWER
BAY
PERTH AMBOY
SOUTH AMBOY
SANDY HOOK
NEWPORT
8

Complainant's Exhibit No. 11.
James D. Maher,
Commissioner.

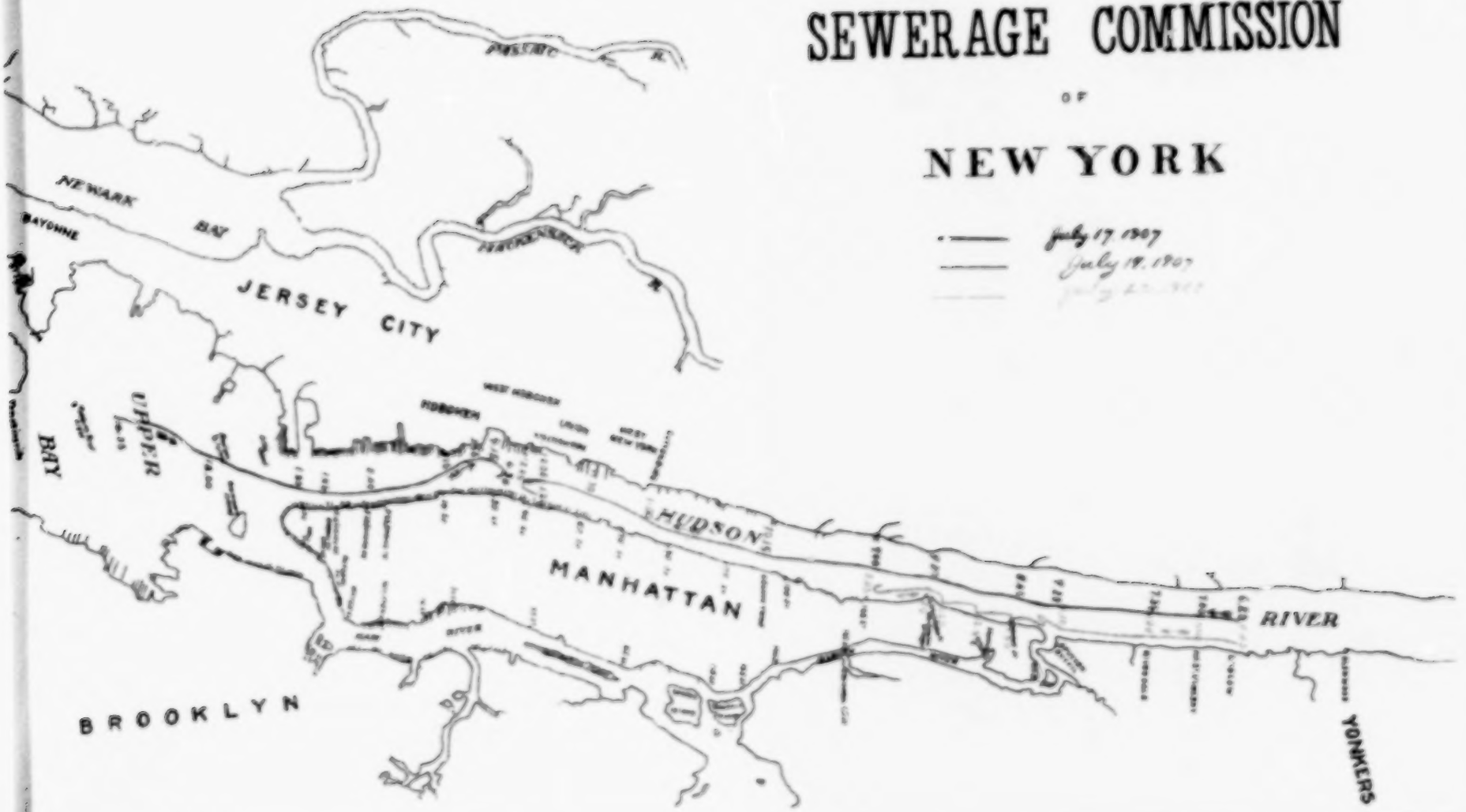
METROPOLITAN SEWERAGE COMMISSION

OF

NEW YORK

July 17, 1907

July 19, 1907



DATA

RELATING TO MUD SAMPLES Nos. 1 to 705

FROM NEW YORK BAY & VICINITY

EXAMINED BY THE METROPOLITAN SEWAGE COMMISSION, 1907

SHEETS 1 to 17 incl.

Complainant's Exhibit No. 14
James L. Maher
Commissioner

1

(1)

Date 1907	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli c.c.	Presumptive B. Coli 1/10 c.c.	Putrescable	Loss on ignition Parts per million by wt.	Color	Odor	Water Temp.	Water Depth	Remarks
Feb 14	1	300' off 51st. Brooklyn	Surface	750 000									
"	2	150' off sewer- 49th St. Bklyn.	"	11000 000									
"	3	Special	"										
"	4	Edge Bay Bridge Chan. 49st.	"	90000									
"	5	Center of Gowanus Bay	"	26000 000									
"	6	Gowanus Canal & 22 st.	"	450 000									
"	7	Battery Slip- Pier A.	"	800000									
Feb. 17	8	Anchorage off Erie Basin	"	370 000									
"	9	" " Gowanus Bay	"	380000									
"	10	" " 49th. St.	"	220 000									
"	11	" " 67th St.	"	460000									
Feb 27	12	Bulkhead - 51st Bklyn.	2'-0"	4000 000				72,080	Black	Sewage	0.5°C.	24 ft.	
"	13	" "	2'-8"	5000 000				69,940	"	Strong "			
"	14	" "	3'-4"	3000 000				46,910	"	Sewage			
"	15	" "	4'-0"	1250 000				25,780	"	"			
"	16	" "	4'-8"	950 000				44.230	"	"			
"	17	Gowanus Canal & Court St.	2'-0"	3000 000				107,403	"	Kerosene	0.75°C.	16 ft.	Torry
"	18	" "	2'-8"	4400 000				99.270	"	"			
"	19	" "	3'-4"	4200 000				107,700	"	"			Much Tar.
"	20	" "	4'-0"	900 000				59.480	"	Sewage & "			Small amount Tar.
"	21	" "	4'-8"	550000				36,250	"	Kerosene			
"	22	Gowanus Canal 300' below Hamilton.	2'-0"	500 000				219,000	"	Strg Coal Tar	0.75°C.	17 ft.	
"	23		2'-8"	950 000				202.400	"	Coal Tar			
"	24		3'-4"	6400 000				183,300	"	" "			
"	25		4'-0"	1650 000				119,300	"	Kerosene			
"	26		4'-8"	900 000				83,790	"	Faint Sewage			
Mol Feb 27	27	Ambrose Channel Lower Bay		2900				59.190	Gray	Odorless		Taken from dredge in 40' water	
Mar. 2.	28	End E. 26 St. Pier E.R. ½ way out.	Surface	950 000				109,000	Black	Faint Sewage		28 ft.	
"	29		"	1700000				204,600	"	" "	2.0°C.	22 ft.	
"	30		2'-0"	850 000				127,100	"	Sew. & Kero.			
"	31		2'-8"	250000				119.200	"	Faint Sewage			
"	32		3'-4"	850000				121,000	"	Aromatic			
"	33		4'-0"	250 000				124.600	"	Sewage			
"	34		4'-8"	250000				108,100	"	"			

* 24ft. = 30ft. 10ft. = 26ft.

(2)

Date 1907	Sample number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli		Putrescible	Loss on Ignition Parts per million by wt.	Color	Odor	Water		Remarks
					I.C.E.	T.C.E.					Temp.	Depth	
Mar. 8	35	Ellis Id. South Slip	Surface	7 700 000				106 100	Black	Sewage	1.0°	15 ft.	
"	36		10"	2 900 000				110 800	"	"			
"	37		18"	3 000 000				108000	"	"			
"	38	Liberty Id. E dock	Surface	2 800 000				99700	"	"		18 ft	
"	39		2'-0"	3 200 000				233900	"	"			Much Tar
"	40		2'-8"	3 000 000				98770	"	"			
"	41		3'-4"	2 800 000				100 000	"	"			
"	42		4'-0"	5 000 000				93 470	"	"			
"	43		4'-8"	2 500 000				110 600	"	"			
Mar. 9	44	East River, foot 24 St.	3'-0"	8 300 000				97 560	"	"		15 ft.	
"	45		3'-8"	4 600 000				106 600	"	Sewage & Refuse			
"	46		4'-4"	1 400 000				101 900	"	" "			
"	47		5'-0"	1 100 000				114 900	"	" "			
"	48		5'-8"	1 200 000				56 860	"	" "			
Mar. 12	49	Blk. Tom Bayonne S. side Nat. Stores	Surface	4 000 000	+	+		137 900	"	" "	0.5° C.	20 ft.	
"	50		0'-4"	2 000 000	+	+		135 900	"	" & gas refuse			
"	51		1'-0"	2 600 000	+	+		172 400	"	" "			
"	52		1'-8"	2 300 000	+	+		190 000	"	" "			Tarry Matter.
"	53		2'-4"	1 900 000	+	+		95 640	"	Sewage			
"	54	Kill von Kull west of Constables Hook	Surface	4 900 000	+	+		102 600	"	Gas refuse			
"	55		2'-0"	2 000 000	+	+		96 160	"	Sewage			
"	56		2'-8"	3 600 000	+	+		98 330	"	"			
"	57		3'-4"	900 000	+	+		87 920	"	"			
"	58		4'-0"	1 900 000	+	+		98 680	"	"			
"	59		4'-8"	3 000 000	+	-		92 130	"	"			
Mar. 15	60	Bet. Ellis & Liberty Id's. 100 yds. from Ellis.	Surface	500 000				68 700	"	Gas refuse	3.0°	10 ft.	
"	61		4'-6"	1 800 000				70 010	D'k. Slate	Fnt. Earthy			
"	62		5'-2"	770 000				56 960	" "	Sewage			
"	63		5'-10"	900 000				59 250	" "	Fnt. Earthy			
"	64		6'-6"	760 000				58 020	" "	" "			
"	65		7'-2"	450 000				56 640	" "	" "			
"	66	Bet. Ellis & Liberty Id's. 1/3 distance from Ellis Id	Surface	930 000				86 150	Black	Gas refuse		8 ft.	
"	67		6'-0"	970 000				72 530	D'k. Slate	Earthy			
"	68		6'-8"	1900000				76000	" "	"			

(3)

Date 1907.	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli		Putrescible	Loss on Ignition Parts per million-by wt.	Color	Odor	Water		Remarks
					.1 C.C.	1 C.C.					Temp.	Depth	
Mr. 15	69	Between Ellis & Liberty Isds. ⅓ dist. from Ellis	7'-4"	2,600,000				73,500	D'k. Slate	Earthy		8 ft.	
"	70		8'-0"	1,500,000				66,800	" "	"			
"	71		8'-8"	500,000				66,050	" "	"			
"	72	Ditto. ⅔ dist. from Ellis.	surface	No count				104,200	Light Slate	sewage		6 ft.	
"	73		5'-0"	1,900,000				72,440	Dark "	earthy			
"	74		5'-8"	1,900,000				68,010	" "	"			
"	75		6'-4"	1,200,000									
"	76		7'-0"	1,600,000									
"	77		7'-8"	1,900,000				66,170	Dark Slate	earthy			
"	78	Ditto. 200 yds. from Liberty Id.	surface	2,800,000				97,600	Black	sewage		6 ft.	
"	79		9'-0"	1,700,000				69,910	Light Slate	earthy			
"	80		9'-8"	1,400,000				56,670	" "	"			
"	81		10'-4"	1,200,000				66,540	Dark "	faint "			
"	82		11'-0"	1,000,000				74,470	" "	" "			
"	83		11'-8"	930,000				68,630	" "	" "			
Mr. 18	84	Back of Ellis Island	surface	800,000				83,150	" "	str'g sewage	2.5°	7 ft	
"	85		5'-0"	1,900,000				69,690	Light "	faint "			
"	86		5'-8"	1,400,000				70,770	" "	" "			
"	87		6'-4"	1,900,000				72,250	" "	" "			
"	88		7'-0"	2,000,000				76,110	" "	" "			
"	89		7'-8"	80,000				74,000	" "	sewage			
"	90	Ditto	surface	30,000				69,900	Black	H_2S "			
"	91	S. of above	3'-6"	118,000				58,870	Light Slate	earthy		8 ft.	
"	92		4'-2"	13,000				57,390	" "	sewage & fishy			
"	93		4'-10"	300,000				58,200	" "	sewage			
"	94		5'-6"	370,000				52,870	" "	"			
"	95		6'-2"	370,000				55,340	" "	faint "			
"	96	Off Jersey between Ellis & Liberty Ids.	surface	1,400,000				60,850	Brown	fishy		6.5 ft.	
"	97		5'-0"	1,800,000				69,830	Light Slate	faint sewage			
"	98		5'-8"	1,300,000				61,000	" "	" "			
"	99		6'-4"	1,800,000				61,960	" "	fishy			
"	100		7'-0"	1,800,000				92,590	Brown	sewage			
"	101		7'-8"	400,000				90,650	Black	Kerosene			
"	90-95	See above	surface to 6'-2"	303,000								8.0 ft.	

(4)

Date 1907	Sample Number	Location	Depth of Sample	Bacteria per gram	Presumptive B. Coli /cc.	Putrescible	Loss on ignition Parts per million dry weight	Color	Odor	Water Temp	Water Depth	Remarks
March 18	96-101	Off Jersey bet. Ellis & Liberty	Surface to 7'8"	At 1,200,000							6 ft 2 in.	
	102-107	" " " " "	" 10'6"	" 600,000			65,000	Bl.-br.	Kerosene & Sewage		6 ft 10 in.	
	108-113	" " near Ellis	" to 10'8"	" 600,000			83,000	Brown	Sewage		6 ft 6 in.	
	114-119	Nearer " N of "	" to 8'8"	" 1,200,000			78,800	Bl - brown	strong "		6 ft 11 in.	surf. putrid
March 26	120	Off communipaw	Surf	2,400,000			342,300	Black	" "	2 3/4° C.	3 ft	very "
	121	1000' N of Ellis Island	4'0"	4,300,000			198,400	Light Brown	earthy			rot
	122		4'8"	3,700,000			92,520	" "	"			
	123		5'4"	2,000,000			98,880	Dark "	"			
	124		6'6"	2,900,000			81,360	" "	"			
	125		6'8"	2,300,000			393,000	Light "	sewage			rot
	126-137	200' E. of above	Surface to 3'2" / 1'2"	At 1,000,000 / 2,800,000			75,000 p.m.	brown	"		12 ft.	
	138-143	250' E. " "	" to 8'8"	At 1,600,000			92,000 p.m.	"	Kerosene & "		13 ft.	
	144-149	200' E. " "	" to 11'2"	" 500,000			90,000 p.m.	Bl. Brown	Sewage		8 ft.	
Total	120 samples in March											
April 1	150-155	100 yards from Black Tom	Surface to 7'8"	1/2 to 2 mil.			78,000 p.m.	Dark brown	Kerosene "	2 1/2° C.	10 ft.	
	158-161	Along Bayonne shore	" to 7'8"	1/2 to 1.8 "			75,000 p.m.	Brown	" & "		7 1/2 ft.	
	162-167	Off " opp Liberty Isl.	" to 7'8"	1/5 to 1.3 "			78,000 p.m.	"	" & "		6 1/2 ft.	
	168-173	" " " Ellis "	" to 5'2"	110,000 to 300,000			85,000 p.m.	"	" & "		7 ft.	
	174-177	" Communipaw	" to 2'6"	300,000 to 1,500,000			80,000 p.m.	Dark brown	" & "		7 1/2 ft.	
April 5	178-183	Jersey 1/2 bet. Liberty & Black Tom	" to 6'2"	1/10 to 2.6 mil.			70,000 p.m.	Bl. brown	gas & "	7° C.	2 ft.	
	184-189	Bay View Cemetery Greenville	" to 5'8"	120,000 to 3 "			90,000 p.m.	" " "	sewage		12 ft.	
	190-195	Bet. lost & Pa. R.R. N. of light Ferry	" to 5'8"	110,000 to 1/2 "			55,000 p.m.	" " "	"		12 ft.	
	196-201	To N of " " "	" to 4'2"	300,000 to 2 "			40,000 p.m.	" " "	Kerosene "		13 ft.	
	202-207	Off " " "	" to 4'2"	550,000 to 2 "			50,000 p.m.	" " "	" & "		12 ft.	
April 11	208-213	Off Bayonne S. of Pa. R.R. " "	" to 6'2"	1,200 to 20,000			65,000 p.m.	Light Brown	" & Sh. "	4 1/2° C.	8 ft. H.	
	214-219	" " toward Constable Hook	to 8'2"	1200 to 80,000			80,000 p.m.	Bl. to "	" & "		7 ft.	
	220-225	" " nearer " "	" to 7'8"	6,000 to 55,000			80,000 p.m.	Bl. to Black	" & "		7 ft.	
	226-231	N. of " "	" to 9'2"	47,000 to 150,000			80,000 p.m.	" "	" & "		7 ft.	
	232-237	Constable Hook nearer Kill v. K.	to 12'8"	4,000 to 117,000			80,000 p.m.	Black	Sh. Sewage		6 ft.	
	238-243	" " Edge of " "	" to 13'8"	4,500 to 74,000			58,000 p.m.	Bl. to Sh.	Kero & "		13 ft.	
April 15	244	Anchorage off Gowanus Bay	Surface	340,000			76,920 p.m.	Black	Sewage & Sh.	5 1/2° C.	18 ft.	
	245		8"	800,000			55,380 p.m.	"	Strong "			
	246		1'4"	270,000			23,310 p.m.	"	" "			
	247		2'0"	120,000			19,650 p.m.	Dark brown	Sewage			Sandy

(5)

Date 1907	Sample No.	Location	Depth of Sample	Bacteria per gram	Presumptive B. Coli 1/10 c.c.	Presumptive B. Coli 1/100 c.c.	Putrescible	Loss on Ignition Parts per m. of Dry matter	Color	Odor	Water Temp.	Water Depth	Remarks
Apr 18	248	Anchorage off 73d Bklyn	Surf.	280,000				34,840	Dark brown	Kerosene	9½°C.	23 ft	Sandy & coal.
	249		8"	270,000				12,150	" "	Sewage "			
	250	150' off 65 St. sewer "	Surf	3,500,000				30,780	Black	" "	12½°C.	18 ft	
	251		8"	1800,000				67,080	"	" "			
	252		1'4"	1500,000				95,750	"	" "			
	253		2'6"	360,000				88,890	"	" "			
	254		2'8"	170,000				67,710	"	" "			
Apr 17	255	Gravesend Bay 100 yds from Marine Dock	Surf.	18,000				17,450	Light Slate	Foul Sewage	8° C.	6 ft	Sandy
	256		2'0"	90,000				26,500	" "	" "			"
	257		2'8"	70,000				58,790	"	decided.			
	258		3'4"	83000				47,103	" "	" "			
	259		4'0"	30,000				53,870	" "	" "			
	260		4'8"	18,000				84890	Black	"			Sandy.
	261	" " 300 ft shore	Surf	45,000				22,280	"	Strong H2S	5°6.	6 ft	
	262	" " Outer end Marine Dock	"	10,000				48,550	Light Slate	Earthy	6°C.	4½ ft	Clean sand.
Apr 19	263	E Side City Dock St George S.I.	Surf	900,000				82,560	Black	Kerosene	6½°C.	9 ft	
	264		6'0"	500,000				61,530	"	"			
	265		6'8"	450,000				54,830	"	"			
	266		7'4"	300,000				72,480	Dark Slate	"			
	267		8'0"	300,000				69,360	Black	"			
	268		8'4"	100,000				54,360	"	Earthy			
	269	S End Pamptonsville S.I.	Surf.	1,500,000				111,100	"	Kerosene	6½°C	9 ft.	
	270		2'10"	600,000				84,000	"	"			
	271		3'6"	500,000				125,200	"	"			
	272		4'2"	300,000				27,130	"	Slight "			
	273		4'10"	450,000				118,000	"	" "			
	274		5'6"	350,000				118,400	"	" "			
	275	S Side near Pier Lower End	Surf.	1,000,000				183,200	"	Strong "	6½°C.	10 ft.	
	276	Shooters Island S.E.	6'8"	400,000				113,600	"	" "			
	277		7'2"	450,000				103,300	"	" "			
	278		7'10"	300,000				102,900	"	" "			
	279		8'8"	200,000				88,980	"	" "			
	280		9'2"	150,000				73,370	"	Slight "			
	281	Foot Slooter Shooters Is	Surf.	1,200,000				105,000	"	Gas rotten	6⅝°C.	10 ft.	

(6)

1916/1917	Sample Number	Location	Depth of Sample	Bacteria per gram	Presumptive B. Coli Gas	Presumptive B. Coli Fecal	Petroleum	Loss on Ignition Part per mill as water	Color	Odor	Water Temp.	Water Depth	Remarks
Apr 18	282	500' from end of Pier	1'0"	300,000				128,400	Black	Kerosene			
	283	½ way in Shore	1'0"	700,000				136,230	"	Gas			
	284		2'6"	500,000				134,200	"	"			
	285		3'0"	358,000				102,000	"	"			
	286		5'6"	200,000				63,450	"	"			
Apr 19	287	St. George S.I. Coal Dock	Surf	1,000,000				112,300	"	Kerosene	57½°C	10 ft.	
	288	½ way in Shore	4'0"	300,000				103,800	"	"			
	289		4'6"	600,000				100,600	"	"			
	290		5'6"	198,000				114,500	"	"			
	291		6'0"	200,000				113,000	"	"			
	292		6'6"	70,000				110,700	"	"			
	293	Dock New Brighton S.I.	Surf	900,000				58,500	"	"	57½°C	7 ft.	
	294		0'0"	1,650,000				111,700	"	"			
	295		0'8"	800,000				87,883	"	"			
	296		2'6"	1,400,000				78,810	"	"			
	297		3'0"	800,000				108,800	Dark brown	"			
	298		3'6"	400,000				84,400	" "	"			
	299	Dock Sailors Snug Harbor S.I.	Surf	300,000				17,850	Light "	Faint earthy			Fine gravel & sand
	300		0"	500,000				41,760	" "	Strong mud			
	301		0'6"	400,000				28,050	" "	" "			
	302		2'0"	350,000				28,750	" "	" "			
Apr 26	303	N.R. Cortlandt St. Ferry and Pier	Surf	450,000	-	+		87,750	Dark "	Sewage	8½°C	24 ft.	
	304	" Fulton St. N end of Pier 5	"	900,000	+	+		118,500	Black	"	8½°C	22 ft.	
	305	" Franklin St. 100' from bulk head	"	800,000	+	+		124,500	"	Kerosene	8½°C	24 ft.	
	306	" Chambers St. ½ way Pier N.R.	"	1,500,000	+	+		112,000	"	" "	8½°C	26 ft.	
	307	" Consumers St. S.R.	"	700,000	+	+		124,400	"	Str. Sewage	8½°C	15 ft.	
	308	" W. 12 St. ½ way in N.R.	"	7,000,000	+	+		104,500	"	" "	8½°C	40 ft.	Very putrid
	309	" W. 30 St. Dumps ½ in S.R.	"	18,000,000	+	+		132,500	"	" "	8°C	20 ft.	veg fibres
	310	" W. 39 St. ¼ ½ " S.R.	"	13,000,000	+	+		133,700	"	Sewage Gas Petrol	8°C	26 ft.	" "
	311	" W. 49 St. S.R.	"	1,000,000	-	+		110,800	"	" " "	8°C	15 ft.	" "
	312	" W. 59 St. S.R.	"	650,000	-	+		131,200	Dark brown	Sewage	8°C	20 ft.	" "
	313	" W. 69 St. S.R.	"	12,000,000	+	+		104,800	" Slate	Str. "	8°C.	30 ft.	" "
	314	" W. 79 St. S.R. 100' out	"	3,600,000	+	+		127,500	Black	" "	8°C.	20 ft.	" "
Total	127 Samples in All												

Date 1907	Sample Number	Location	Depth of Sample	Bacteria per gram	Presumptive B Coli 1 CC.	Presumptive B Coli 1 CC.	Putrescible	Loss on Ignition Part per mil by weight	Color	Odor	Water Temp.	Water Depth	Remarks
May 10	315	Sluiceway Sewer Great Drain	Surf	288,000	–	+		48,840	Dark gray	earthy	10 4/4° C.	20 Ft.	
	316	of N River	8"	28,000	–	+		54,650	" "	"			
	317		4.0"	2,000	–	–		42,680	" "	"			
	318		2.0"	12,000	–	–		42,890	" "	"			
	319		3.0"	2,000	–	–		48,700	" "	"			
	320		4.0"	8,000	–	–		50,000	" "	"			
	321	Bldg of Randolph Johnson[illegible]	Surf	580,000	+	+		168,100	Black	Sew & oil	11 3/4° C.	6 Ft.	
May 13	328	Nav. Ft. 100'E. of Bridge	Surf	450,000	+	+		34,240	"	Sewage			Coarse Sand
	329		1.0"	300,000	+	+		58,180	"	Stf. "			
	330		2.0'	1,900,000	+	+		818,600	"	— "			Deer Bay.
	331	Harlem Ft. Foot 181st St	Surf	900,000	+	+		18,810	Dark Brown	" "	11° C.	11 Ft	Sandy
	332		1.0"	400,000	+	+		41,480	"	" "			
	333		2.0"	800,000	+	+		61,750	"	"			
	334		3.0"	350,000	–	+		38,480	"	"			
	335		4.0"	250,000	–	+		53,370	"	"			
	336	" " W 207st 100' N of Bridge	Surf	700,000	+	+		61,780	"	"	11° C.	4 Ft.	
	337		1.0"	700,000	–	+		102,600	Black	"			
	338		2.0"	400,000	+	+		92,420	Dark Brown	"			
	339		3.0"	300,000	–	–		98,300	" "	Fecal "			
	340		4.0"	800,000	–	–		103,400	" gray	" "			
	341		5.0"	400,000	–	+		97,150	" "	" "			
	342	" " 69th St 115th 100' from N Shore	Surf	800,000	+	+		104,600	Black	Sewage & gas retort	11° C.	6 Ft.	
	343		1.0"	200,000	+	+		58,980	Dark Brown	"			
	344		2.0"	850,000	+	+		98,230	" "	"			
	345		3.0"	300,000	+	+		103,100	" "	Fecal gas			
	346		4.0"	350,000	–	+		73,580	" "	" " & oil			
	347		5.0"	350,000	–	–		105,100	" "	" " & "			
	348	" " under Main Bridge	Surf	1,000,000	+	+		111,509	Black	Petroleum	11 3/4° C	4 Ft.	
	349		1.0"	300,000	+	+		120,000	"	Stf. "			
	350		2.0"	400,000	+	+		108,300	"	" "			
	351		3.0"	300,000	+	+		101,800	"	" Sewage			
	352		4.0"	400,000	+	+		91,810	Dark Brown	Petr. & Sew.			
	353		5.0"	300,000	–	+		108,400	" "	" & "			
	354		6.0"	200,000	+	+		85,120	Black	" & "			

(8)

Date 1907	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B.Coli .1 C.C.	Presumptive B.Coli 1 C.C.	Putrescible	Loss on Ignition Part per mil. by weight	Color	Odor	Water Temp.	Water Depth	Remarks.
May 13	355	Har. Rir. under High Bridge E. Shore	Surf	700,000	+	+		76,720	dark brown	faint earthy	11 1/4 °C	6 ft.	
	356		1'-0"	400,000	-	+		82,830	Light "	" "			
	357		2'0"	350,000	-	-		78,840	" "	" "			
	358-362	" " opp 165 St E Shore	Surf to 4'-0"	N. 250,000	+	+		100,000+	bl dark gray	Sewage	11 1/2 °C	4 ft.	
May 14	363-368	" " Putnam R.R. Br. N. "	" to 5'-0"	100,000 to 700,000	+	+		95,000±	bl. light	" Steres	12°	2 ft.	
	369-374	" " Below N.Y. Central Br.	" to 5'-0"	200,000 to 400,000	+	+		95,000±	bl-dark br.	" "	12°	2 ft.	
	375-381	" " foot W. 143 St	" to 6'-0"	200,000 to 2,000,000	+	+	yes	145,000±	black "	" "		12 ft.	
	382-384	" " Mod Av. Bridge	" to 2'-0"	250,000 to 400,000	+	+		142,800	" to gray	gas refuse	13°	12 ft.	
	385-391	" " foot 153 St W. Shore	" to 6'0"	600,000 to 2,200,000	+	+		132,700	" to brown	H2S gas	13°	8 ft.	putrid
	392-395	" " Randalls Id. Pier	" to 3'-0"	350,000 to 2,000,000	+	+	yes	186,500	black	Sewage "		6 ft.	putrid
	396-399	N.Y. Bay Back of Ellis Id.	" to 3'-0"	400,000 to 1,800,000	+	+		89,840	" to gray	earthy	11° C	20 ft.	
May 15	400	Hoctel Dock above N.Y.C. R.R.	Surf	2,100,000	+	+		113,800	black	sew & gas			
	401	Jersey City	1'-0"	1,300,000	+	+		125,000	dark br.	Str. earthy			
	402		2'0"	600,000	+	+		81,750	"	Sewage "			
	403		3'0"	700,000	+	+		118,800	"	"			
	404		4'-0"	600,000	+	+		113,800	"	Str. moldy			
	405		5'0"	300,000	+	+		102,400	" gray	" Sewage			
May 22	406	Gravesend Bay 300's Marine Basin	Surf	300,000	+	+		90,060	Light "	"	17°6.	6 ft.	Corse Sand
	407	" " near Coney Id. Creek	"	350,000	+	+		70,920	dark brown	H_2S	17°C.	5 ft.	Sand
	408	" " entrance to Coney Id. Creek	"	800,000	+	+		93,240	" "	"	17°C.	5 ft.	Sand
	409	Coney Id. Creek near mouth	"	1,200,000	+	+		23,960	black	"	18°C.	6 ft.	"
	410	" " " " "	1'-0"	1,500,000	+	+		42,180	"	"	19°C.	6 ft.	"
May 23	411	Slip Conover St. Brklyn	Surf.	700,000	+	+		34,830	"	Sewage	19°C.	6 ft.	"
	412		1'-0"	3,000,000	+	+		104,500	"	"			
	413		2'-0"	3,000,000	+	+		124,700	"	Str. "			
	414		3'-0"	3,200,000	+	+		127,800	"	"			
	415		4'-0"	2,800,000	+	+		116,500	"	"			
	416		5'-0"	1,110,000	+	+		78,200	"	"			
	417	Slip Sedjmck St. "	Surf.	6,000,000	+	+		142,900	"	Sewage "	19°C.	16 ft.	
	418		1'-0"	7,700,000	+	+		165,200	"	Sewage "			
	419		2'-0"	4,000,000	+	+		153,500	"	" & "			
	420		3'-0"	3,000,000	+	+		143,100	dark brown	Str. mouldy			
	421		4'0"	2,500,000	+	+		158,100	black	" "			
	422	Slip Stole St. "	Surf.	9,500,000	+	-		176,300	"	earthy & gas	19°C.	12 ft.	

Ex. 14-P 8

(9)

Date 1907	Sample number	Location	Depth of sample	Bacteria per gram	Presumptive B Coli. I.C.C.	Presumptive B Coli. N.E.	Putrescible	Loss on Ignition Parts per mil. by weight	Color	Odor	Water Temp.	Water Depth	Remarks.
May 23	423		1'-0"	12,000,000	+	+		174.300	Black	earthy			
	424		2'-0"	5,400,000	+	+		182,800	"	"			straw
	425		3'-0"	4,800,000	+	+		187.600	Light brown	& gas			
	426		4'-0"	4,300,000	+	+		186,800	black	"			
	427		5'-0"	4,400,000	+	+		135.200	Light brown	"			veg. fibres.
	428		6'-0"	1,600,000	+	+		234,200	black	"			
	429	Slip Clark St. Bkfst	surf.	19,000,000	+	+		232.400	"	"	19°C	25 ft.	Wood
	430		1'-0"	8,000,000	+	+		167.900	Light brown	" & "			
	431		2'-0"	7,000,000	+	+		214,600	" "	" & "			
	432		3'-0"	5,400,000	+	+		151,500	" "	earthy			
	433		4'-0"	3,800,000	+	+		133.100	" "	"			
May 29	434	E.R. 47 St. Slip Bkfst ooze	surf	5,800,000	+	+		181,800	black	very putrid	12°C.	1/4 ft.	
	435	" " middle opp 47 St. Brown sand	"	200,000	−	−		11,070	Light brown	fish	11½°C.	90 ft.	coarse sand
	436	" " 42 St. Slip Bkfst ooze	"	6,000,000	+	+		92.290	black	very putrid	13°C.	14 ft.	
	437	" " 62 St. Slip, 20' from shore Bkfst. ooze	"	15,000,000	+	+		166,000	"	" " & gas	13°C.	17 ft.	straw
	438	" " 62 St. Pier 20' from shore Bkfst. ooze	"	18,000,000	+	+		104,000	"	" " & "	13°C.	30 ft.	
	439	" " middle opp 35 St. brown sand	"	400,000	−	−		166,700	Light brown	faint sew.	13°C.	30 ft.	Sand
	440	" " anchorage off 26 St. brown sand & gravel	"	700,000	−	−		—	—	odorless	13°C.	30 ft.	
Total	126 Samples in May												
June 4	441	Slip W. 50 St. inner end	surf	4,200,000	−	+	Yes	96.650	black	sewage	18½°C.	10½ ft.	
	442	" " Pier head	"	3,400,000	+	+	"	150.100	"	" & gas	18°C.	30 ft.	strongly putrescible
	443	300' off " "	"	2,700,000	+	+	"	133.900	"	" & "	18°C.	35 ft.	
	444	500' " " "	"	700,000	−	+		—	dark gray	earthy	18°C.	40 ft.	coal & ashes
	445	midstream off 50 St.	"	300,000	+	+		112.700	black	sew & gas	18°C.	45 ft.	paper pulp
	446	" " 42 St. N. River	"	200,000	−	+		60.760	dark gray	earthy	18°C.	40 ft.	
	447	" " 34 " " "	"	150,000	+	+		—	—	—	18°C.	40 ft.	very small shells
	448	" " 23 " " "	"	200,000	+	+		89.500	black	mouldy	18°C.	40 ft	
	449	" " 14 " " "	"	180,000	+	+		98.260	"	str. sewage	18°C.	60 ft	strongly putrescible
	450	" " Houston " "	"	220,000	+	+		91.850	gray	earthy	18°C.	60 ft.	coal & ashes
	451	" " Pier "O" " "	"	350,000	+	+		119.800	black	strong sew.	18°C.	45 ft	fine ooze
June 5	452	Anchorage of Erie Basin	"	800,000	+	+		27.670	dark brown	" "	18°C.	25 ft.	" sand mica scales
	453	" " Gowanus Bay	"	400,000	+	+		88.430	black	" H_2S	18°C.	35 ft	" " many shells
	454	" " 39 St. Bkfst	"	400,000	+	+		125.200	"	" sewage	18°C.	30 ft.	" " " "
	455	" " 53 St. "	"	300,000	+	+		86.860	"	" "	19°C.	25 ft.	very putrid

(10)

Date 1907	Sample number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli +C.C.	Presumptive B. Coli T.C.	Putrescible	Loss on Ignition parts per mill. by weight.	Color	Odor	Water Temp.	Water Depth.	Remarks
June 5	456	Anchorage off 67 St. B'klyn.	surf	200,000	+	+		31,270	black	strong sew	18° C.	30 ft.	ashes, coal sand, shells
	457	" " 72 " "	"	95,000	+	+		45,880	"	" H_2S	18° C.	40 ft.	ooze, sand & wood
	458	" " 79 " "	"	109,000	+	+		350,400	"	gas refuse	18° C.	40 ft.	
	459	" " 92 " "	"	85,000	+	+		19600	dark grey	sewage	18° C	35 ft	shell fragments gravel & coal
	460	" " middle of Narrows opp. Ft Ham.	"	80,000	+	+		31,120	" brown	"	18° C.	60 ft.	sandy
June 6	461	Slip 10 St. E. River Sat with oil from gas works	"	3,200,000	+	+	Yes	—	—		17½° C.	12 ft.	
	462	" 23 St. " " S.S. Pennsylvania Pier	"	1,200,000	+	+	" & bubbles	—	—		18° C.	15 ft.	
	463	midstream opp 42 St. E. River	"	25,000	−	−		14,340	Light brown	mouldy			coarse sand
	464	Newtons Cr. above Meeker Av. Br. Sat. with oil from S.S. Pennsylvania	"	4,000,000	+	+	"	260,000	black	gas & H_2S			very putrid
June 12	465	Slip 10 St. E. Riv. inner end	"	240,000	+	+		241,000	"	sewage	14½° C.	12 ft.	oily ooze very putrid
	466	" " " " pier head	"	120,000	+	+		158,800	"	"	14° C.	20 ft.	" " " "
	467	50' off " " "	"	200,000	+	+		43,940	—	Str. mouldy	14° C.	30 ft.	coarse sand & gravel Tarry mat.
	468	Slip 12 St. E.R. inner end	"	130,000	+	+		202,400	black	" tarry	14½ C.	12 ft.	black ooze
	469	" 13 " " " "	"	500,000	+	+		242,200	"	" sewage	14½° C.	12 ft.	veg. fibres & Tarry mat
	470	" " " pier head	"	9,500	0	0		58,470	Light yellow	H_2S	14½° C.	20 ft.	clay
	471	" 22 St. E.R. inner end	"	170,000	+	+		206,400	black	tarry	14½° C.	30 ft.	ooze, fiberous
	472	" " " " pier head	"	100,000	0	0		120,000	"	Str. Sewage	14½° C.	30 ft.	ooze
	473	" 61 St. E.R. inner end	"	57,000	+	+		139,800	"	" "	14½° C.	23 ft.	ooze very putrid
	474	" 42 St. " " "		300,000	+	+		100,530	"	" mouldy	14½° C	20 ft.	bl ooze & gravel
	475	" 9 St. " pier head		60,000	+	+		103,000	"	sew. & H_2S	14½° C	20 ft.	" " & coal

N.B. Gas works 9th - 13th Sts, 22nd St, 42nd St & 61st Sts. Samples taken in these slips were all black oily ooze with a strong odor of tar & illum. gas except #470 which was clay like consistency, color of terra cotta. When dry had no odor. Black ooze from several million bacteria per gram. That from 22nd St. where gas waste was plentiful only 170,000.

June 17	476	Newton Cr Mct Av Br. only ooze	surf	3,000,000	+	+	Yes	205,430	black	burnt rubber	17½° C.	10 ft.	Putrescible oily ooze
	477	" " Newtons. " "	"	1,500,000	+	+	"	209,650	"	gas odor	17½° C.	12 ft.	oily green mould oily ooze putrescible
	478	" " Meeker Av Br - mud	"	1,500,000	+	+	"	153,200	"	" " very strong	17½° C.	4 ft.	" oily mud "
	479	" " 1000' above Greenpoint Av. B'klyn S.S.	"	500,000	?	?	"	239,570	"	gas odor. very strong	17½° C.	15 ft.	" Tarry matter "
	480	" " 500' " " " "	"	1,000,000	0	0	"	100,500	Yellow	burnt rubber	17½° C.	15 ft.	clay
	481	" " 50' below " " S.S.	"	5,000,000	+	+	"	44,193	black	str. gas	17½° C.	15 ft.	Oily
	482	" " Vernon Av Bridge	"	50,000	0	0		44,610	"	H_2S	17½° C.	15 ft.	Best Pea Coal Co. mix oil cool & ashes
	483	" " 500' below " "	"	2,900,000	0	0		106,770	grey	mouldy	17½° C.	15 ft.	oily sand sand, gravel, ashes, grav
	484	" " middle of mouth.	"	1,000,000	+	+		62,480	brown	"	16½° C.	30 ft.	oily sand clay
	485	E Riv 500' off Newtown Cr	"	2,000,000	+	+		33,945	"	"	16½° C.	50 ft.	oily Sand ashes. coal, tarry matter
June 18	486	Hallotaut Bay #3. foot John St.	"	1,300,000	+	+	Yes	66,580	"	"	16½° C.	40 ft.	fine sand gas works

(11)

Date 1907	Sample number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli 10 C.C.	Presumptive B. Coli 1 C.C.	Putrescent	Loss on Ignition parts per million	Color	Odor	Water Temp.	Water Depth	Remarks
June 19	487	Hollabird Bay E.S. Rail Crossing	Surf	2,300,000	+	+	Yes	851,590	Black	Str. gas	17½° C.	20 ft.	black mud, muck oil
	488	" " E.S. " Division	"	4,000,000	+	+	"	326,300	dark brown	" mouldy	17½° C.	25 ft	moulds & oil
	489	" " near Hollabird mar line	"	25,000,000	0	0	"	239,995	"	Faint sewage	17½° C.	20 ft	veg. fibres
	490	" creek upper end	"	11,000,000	+	+	"	223,550	black	Fr. S	17½° C.	15 ft.	muck & clay
	491	" " Wash. Ave. Bridge	"	25,000,000	0	0	"	240,400	dark brown	Str. sewage	17½° C.	15 ft.	grain &c.
June 26	493	500 N.E. Robbins Reef N.Y. Bay	"	500,000	+	+		101,500	grey	very " "	19° C	35 ft.	clay
June 28	494	1 mile N. St George S.I. " "	"	220,000	+	+		63,800	"	Sewage	19° C.	35 ft	
	495	100' off South Beach S.I. " "	"	50,000	−	−		35,590	black	gas	19°	6 ft	mud & many shells
June 27	496	midstream off 72 St N.River	"	1,000,000	+	+		72,800	grey	earthy	18½° C.	30 ft.	
	497	Sharpton Buoy at Gr. Drum Ent. of marsh	"	180,000	0	0		58,160	"	woody	19° C	18 ft	
	498	Harlem River midstream 100' below High St.	"	360,000	+	+		150,380	" & red	Str. Sewage	19° C.	18 ft.	clays
	499	" " " under	"	230,000	+	+		53,490	—	Slight fishy	19° C.	20 ft	coars sand
	500	" " " 215 St.	"	140,000	+	+		6,379	—	" earthy	19° C.	20 ft.	clean " "
	501	" " " Pitman St.	"	800,000	+	+		14,240	dark grey	gas	19° C.	20 ft	fine sand & mud
	502	" " " High Bridge	"	100,000	−	+		3,368	dark grey	odorless	19° C.	20 ft.	sand
Total	Samples	62 in June											
	503	Gas Buoy #2 N.E. Robbins Reef	"	15,000				22,000	—	Str. Sewage	22° C.	50 ft.	fine gravel & shells
	503-515	Stapleton 100' off Newdock	"	45,000				44,030	Red	gas & "		40 ft.	red clay
	505	500' off upper Quarantine dock	"	370,000				102,400	black	Str. H2S		60 ft	muck very putrid
	506	Narrows off Ft. Wadsworth	"	40,000				59,680	"	Sew & gas		60 ft	clay " "
	507	Bell Buoy just outside Narrows	"	150,000				52,390	"	"		60 ft	" "
	508	200' E. Buoy #3 Lower Bay	"	60,000				31,190	dark brown	Str. mouldy		50 ft	"
	509	700' E. Hoffman Id. " "	"	45,000				22,840	black	Sew. & gas		50 ft.	shells, gravel, some very bad odor
	510	1000' further out " "	"	7,500				6,798	brown	none		60 ft	" clean sand
	511	200' E. off Spikes Id. Hoffman Id.	"	60,000				72,710	black	Sew & gas		50 ft	very bad looking mud
	512	500' S.E. Buoy #3 outer end	"	220,000				83,370	"	" & "		60 ft	
	513	Narrows opp. Ft. Wadsworth Narrows	"	70,000				39,080	"	H2S & gas		60 ft.	putrid
	514	#2 gas Buoy off Pa. R.R. Jamaica	"	150,000				57,310	"	Sewage	22°		oil muck & sand
	515	1000 ± ft. north of above	"	160,000				33,630	"	H2S "	22°		" & clay
	516	2000 ± ft. S. of Liberty Id.	"	350,000				172,420	"	Creosote	"		" fibres
	517	Bell Buoy 500' S. " "	"	630,000				11,200	"	Str. H2S	"		" & clay
	518	200' S.E. " "	"	540,000				38,570	"	" gas			" & sea shells
	519	main channel W.S. opp. " "	"	80,000				41,110	"	Faint sew & gas			Sand coal ashes
	520	" " center " " "	"	100,000				124,200	"	Str. gas			Stone & coal

3194

Ex. 14 - P. 11

(12)

Date 1907	Sample number	Location	Depth of sample	Bacteria per gram	Presumptive B coli .1 C.C.	Presumptive B coli 1.0 C.C.	Putrescible	Loss on Ignition Parts per milligram	Color	Odor	Water Temp.	Water Depth	Remarks.
July 16	521	main channel U.S. opp Liberty Surf	Surf	4,400,000				34,850	black	gas			mud, ashes, coal
	523	" " opp Atl. Basin Buoy	"	120,000				88,030	"	H_2S			mud, green mould
	523	" " " Erie "	"	100,000				65,520	"	Str. "			" quite putrid
	524	" " " " -500' "	"	80,000				89,120	dark brown	gas			" & clay
	525	" " " Governors	"	1,000,000				84,830	Black	slight sew			" & green mould
	526	" " " 39th St. Bklyn	"	1,800,000				25,960	"	gas			" & sand
	527	" " " 53 " "	"	700,000				10,620	dark brown	"			" & ashes
	528	E. anchorage opp 53 St. Bklyn	"	3,400,000				39,500	Black	Str. Sewage			" & sand
July 17	529	12 gas Buoy Liberty 67 ft.	"	550,000				52,260	"	gas & "	82°		" ashes, shells
	530	" " " " Constable Hook	"	6,000,000				83,370	brown	Str. mouldy			clay, odor strong
	531	500' N.E. of above	"	2,500,000				31,130	Black	very Str. H_2S			much shells, ashes
	532	Short dist N.E. of above	"	300,000				41,970	"	Sewage			" " "
	533	main channel S.E. of Liberty 1st	"	300,000				55,630	dark brown	" "			" " "
	534	" " 500' NE of above	"	120,000				149,060	" "	Str. "			" coal very putrid
	535	" " Bet Ellis, Governors Is.	"	110,000				104,030	" "	" "			" " ashes very putrid
	536	1000' off Pier 7 North River	"	150,000				69,380	Black	" mouldy			ashes & cinders
	537	600 " " 23 " "	"	190,000				42,600	brown	"			" & "
	538	300' " " 42 " "	"	60,000				61,312	Black	H_2S			much & coal
	539	midstream opp. 27 St. " "	"	70,000				41,140	"	" & mouldy			chiefly ashes
July 18	540	N. Riv. opp Mt. St. Vincent	"	100,000	0	+		73,390	dark grey	faint sew.			fine mud
	541	" " " Riverdale	"	230,000	0	+		80,900	Black	Str. H_2S			much & clay
	542	" " " Spuyten Duyvil R.R.	"	200,000	+	+		78,530	"	" "			" & "
	543	" " " " Brew Bridge	"	260,000	+	+		85,450	"	sew & "			" & "
	544	" " " Inwood	"	300,000	+	+		73,390	"	" & "			" & "
	545	1/2 out N.J. Shore Weehawken	"	290,000	+	+		75,190	"	" & "			" & "
	546	1/2 " " " " "	"	1,200,000	+	+		101,760	dark grey	Str. mouldy			clay
	547	midstream N.E. opp W. 6 St.	"	800,000	+	+		77,180	brown	Sewage			much & "
	548	1/2 out N.J. Shore " " 133 "	"	1,200,000	+	+		86,110	grey	sewage			"
	549	midstream " " " 123 "	"	2,300,000	+	+		98,050	dark "	Str. mouldy			"
	550	" " " " 108 "	"	650,000	+	+		70,100	" "	"			"
	551	" " " " 93 "	"	800,000	+	+		83,970	" "	Sewage			ashes & cinders
	552	" " " " 80 "	"	400,000	+	+		61,090	Black	gas			" & coal
	553	" " " " 68 "	"	1,600,000	+	+		81,570	"	very Str. Sew			mud & cinders
	554	" " " " 48 "	"	230,000	+	+		53,070	dark grey	faint Sew			" & clay

824

(13)

Sample Number	Location	Bottom Sample	Bacteria per gram	Presumptive B. Coli 10cc	1cc	Putrescible	Iodine as Iodides Parts per million max.	Color	Odor	Water Temp.	Water Depth	Remarks
535	N. Fix. 400' off Jaques Rocks	Soft	110,000	+	+		69.010	brown	Str. sewage	23½°		mud & clay
536	" " 200' " Pennsylvania Ave.	"	170,000	+	+		89.010	black	" "			" & gravel
537	" " 200' " Bathing Beach	"	200,000	+	+		89.101	"	" "			" & clay
538	" " 150' " Mill St. pier	"	150,000	+	+		60.230	"	" "			mud, coal ashes
539	" " 100' " Riverside R.R. dock	"	130,000	+	+			—	none			shells & clean mud
540	" " 150' " R.R. Ferry	"	430,000	+	+		62.850	black	Str. sewage			mud & clay
541	" " 100' " Lehigh Depot dock	"	300,000	+	+		62.910	dark br.	Str. sewage			" "
542	" " 50' " Linwood Dock	"	1,000,000	+	+		62.618	black	Faint H2S "			" & ashes
543	" " 150' off pier midway bet. N. Black Rock	"	550,000	+	+		53000	dark br.	" & "			" & fine sand
544	" " 1500' " " 100' "	"	560,000	+	+		54,930	" "	very str. "			" & clay
545	" " 500' W. 19 Dock	"	470,000	+	+		63,540	" "	Slight "			" & ashes
546	" " 1000' 400' 115° off	"	690,000	+	+		58.200	" "	" "			sand & clay
547	E. Fix. 800' off Niagara Dock	"	300,000	—	+		60.830	black	Str. gas	8.0°		mud other sand for. paper
548	" " 200' " " "	"	180,000	—	+							
549	" " 450' " Pennsylvania Ave.	"	290000	—	+							
550	" " Head of Main St.	"	450,000	—	+							
551	" " " " Buoy	"	300,000	—	+							
552	" " S. End Blackwells Isl.	"	19000	0	+							
553	450' off Standard Oil Dock	"	1800,000	—	+							
554	E. Channel off E. 10 St.	"	159,000	0	+							
555	Outer Bay near N. Black Rock Light		40,000	0	+							
556	" " " Elm Tree Bay	"	60,000	0	+							
557	" " E. of " " "	"	45,000	0	+							
558	" " near old Breakwater Light	"	22,000	0	+							
559	Midway bet. Black & Elm Tree	"	29,000	0	+							
560	" " off Elm Tree Beacon	"	40,000	0	+							
561	" " W. off Jamaica Isl.	"	5,000	0	+							
562	" S. off " "	"	20,000	0	+							
563	Pier Head Rocky Land St.	"	29,000	0	+							
564	Buttermilk channel E. of Gowanus Bay	"	5,000		+					11.0°/2°C.		Sand & gravel
565	E. Fix off Gov. Isl.	"	62,000		+							" & "
566	Upper Bay E. off Robbins Reef	"	380,000	+	+							
567	Narrows off Ft. Hamilton	"	1,000,000	+	+	No						
568	Outer end E. Anchorage	"	2,800,000	+	+	—						

(14)

Sample number	Location	Depth of Sample	Bacteria per gram	Presumptive B Coli 10cc	Presumptive B Coli 1cc	Putrescible	Loss on Ignition parts per million	Color	Odor	Note: Temp.	Note: Depth	Remarks.
589	Sy Spiler Buoy N of Ent.	Surf	1,400,000	+	+	Yes						
590	Ambrose Lgt S of	"	1,700,000	+	+	"						
591	" S of Robbins Reef Light	"	1,400,000	+	+	"						
592	" E. " " " "	"	1,100,000	+	+	"						
593	" near Bell Buoy	"	1,000,000	+	+	"						
594	" abt 63 St	"	1,300,000	+	+	"						
595	see chart	"	860,000	+	+	"						
596	Anchorage off Gowanus	"	3,000,000	+	+	"						
597	" " Erie Basin	"	1,400,000	+	+	"						
598	" " 53 St.	"	1,000,000	+	+	"						
599	" E. of Fast	"	1,000,000	+	+	"						
600	" near Bliss shore	"	1,300,000	+	+	"						
601	see chart	"	1,000,000	+	+	"						
602	" "	"	1,300,000	+	+	"						
603	" "	"	1,700,000	+	+	"						
604	" "	"	1,900,000	+	+	"						
605	" "	"	1,000,000	+	+	"						
606	" "	"	1,900,000	+	+	"						
607	" "	"	1,700,000	+	+	"						
608	" "	"	1,500,000	+	+	"						
609	" "	"	1,000,000	+	+	"						
610	" "	"	1,300,000	+	+	"						
611	" "	"	1,200,000	+	+	"						
612	" "	"	1,000,000	+	+	"						
613	about 1000 ft S.W. of Pier 48 (18 Pier N. of Bush Erie Basin)	"	1,000,000	+	+	"						
614	" "	"	1,900,000	+	+	"						
615	" "	"	1,400,000	+	+	"						
616	" "	"	1,400,000	+	+	"						
617	" "	"	1,400,000	+	+	"						
618	1/2 way bet. Statue Gas Tel & Pier	"	1,500,000	+	+	"						
619	1/2 " " Castle Pt " & Red mid ground	"	1,600,000	+	+	"						
Not Samples left in July		"										
620	Ambrose channel 2000' S.E. Spar Buoy	"	240,000								35 ft.	Sample taken from dredge
621	" " " " "	Deep	110,000								35 ft.	

(15)

Date 1907	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli 1 c.c.	Presumptive B. Coli 1/10 c.c.	Putrescible	Loss on Ignition parts per mil by weight	Color	Odor	Water Temp.	Water Depth	Remarks.
Aug 21	622	Ambrose Channel 200' S.E. 90S buoy	Deep	2,800								35 ft.	
	623	" " 200' S " " #4	Surf.	1,600,000	+	+						26 ft.	Samples taken from dredge
	624	Edge " 50' N of Some Ann " #2	"	54,000								18 ft.	
	625	Edge " " " "	"	350,000	+	+						28 ft.	mud mud bottom
Aug 30	626-636	Ambrose Channel 11 samples	"		-	+	Not						
		taken in 35°-44' water from Swinburn Jd.											
		to 90S buoy #2 gore N.W. of		17,300									
		all of these locations previously dredged											
	637-639	3 samples taken in 32°-34' water on			+	+	Yes						
		edge or just outside of channel											
		gore		1,670,000									
		Note says decomposed garbage dumped here.											
		Bed of channel now clean sand - above 3											
		samples taken from black mud on edge											
		may have been moved by dredges -											
		No exam could be made of shoals											
		away from channel as boat draw											
		13 ft.											
Total	Samples	20 in August.											
Sept 3	640	Hollabout Bay from Division	Surf	5,700,000			Yes				23°	15 ft.	
	641	" " " Cross St	"	3,800,000			"					15 ft.	
	642	" " of Market	"	5,100,000			"					15 ft.	
	643	All Basin foot Conal St.	"	4,000,000			"					30 ft.	
	644	" " " William St.	"	2,800,000			"					30 ft.	
	645	" " " Commerce St.	"	3,100,000			"					26 ft.	
	646	Erie " S.W. Cor.	"	1,600,000			"					25 ft.	
	647	" " N.E. "	"	4,000,000			"					22 ft.	
Sept 4	648	Coney Id. Creek mouth	"	3,800,000			"				23°	8 ft.	
	649	Gravesend Bay midway bet. Yacht Club & C.I. Creek	"	600,000			"					6 ft.	
	650	" " 200' off Yacht Club	"	150,000			Not					6 ft.	
	651	Gowanus " center	"	13,000,000			Yes					30 ft.	
	652	" Canal " 300' below Hamilton Ave	"	5,000,000			"					21 ft.	
	653	" " pool 20 St.	"	11,000,000			"					24 ft.	
Sept 5	654	Kill Van Kull 50' off New Brighton	"	3,900,000			"					15 ft.	

Ex. 14 - P. 15

(16)

/10 /17	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli 1/55	1/5	Putrescible	Loss on Ignition parts per mil. by weight	Color	Odor	Water Temp.	Water Depth	Remarks.
4.5	655	still Pas Fed 50' from Constable H.	Surf	2,500,000			yes					5 ft.	
4.6	656	Hard Pir. bet 3 & 4 Av. 50' from S.	"	3,300,000			"				23½°C.	12 ft.	
	657	" " " 3 & 4 " midstream	"	4,000,000			"					22 ft.	
	658	" " " 3 & 4 - 50' from N.S.	"	3,400,000			"					21 ft.	
4.10	659	Narrows 300' off Ft. Hamilton	"	300,000			"				22½°	10 ft.	
4.11	660	Newtown Cr. Johnson & Morgan Av.	"	2,700,000			"				22½°	15 ft.	
	661	" " Metrop. Ave. Bridge	"	1,800,000			"					16 ft.	
	662	" " Hospital " "	"	2,200,000			"					20 ft.	
	663	" " Meeker " "	"	2,000,000			"					19 ft.	
	664	" " Greenpoint " "	"	1,300,000			"					17 ft.	
4.12	665	Nor. Riv. Pier head 11th St. Pendleton	"	4,400,000			"					5 ft.	
	666	" " midway bet 2 & 3 Av. Bridges	"	5,000,000			"					22 ft.	
	667	" " " " 4 & Med. Av. "	"	4,800,000			"					22 ft.	
	668	" " " " 145 & 155 Sts.	"	2,700,000			"					21 ft.	
	669	" " foot Dyckman St	"	1,900,000			"					17 ft.	
	670	" " Kingsbridge	"	1,200,000			"					19 ft.	
4.25	671	Newark Bay off Shooters I.	"	700,000	+	+	"				22½°	30 ft.	
	672	" " " Centerville	"	80,000	0	+	not					22 ft.	
	673	" " " Buoy #4	"	1,200,000	+	+	yes					12 ft.	
	674	" " " " #11	"	1,700,000	+	+	"					15 ft.	
	675	Passaic River at mouth	"	2,800,000	+	+	"					8 ft.	
4.26	676	North River Spuyten Duyvil Station	"	86,000	+	+	not				20°	40 ft.	
	677	" " " " ½ way	"	67,000	+	+	yes					24 ft.	
	678	" " " " ¾ "	"	96,000	+	+	"					22 ft.	
	679	" " " " 100' from Jersey Shore	"	86,000	+	+	"					13 ft.	
4.27	680-684	Old reservoir Central Park	Surf	67,000 to 432,000 +	+	+	not					12 ft.	
Total	Samples	42 in Sept.											
4.1	68-	Gowanus Canal Degnon St.	Surf	19,000,000	+	+	yes				25°	15 ft.	
	686	" " Union St. Bridge	"	43,000,000	+	+	"					15 ft.	
	687	" " Carroll St. "	"	14,000,000	+	+	"					11 ft.	
	688	" " 3rd St. "	"	12,000,000	+	+	"					13 ft.	
	689	" " Ham. Av. "	"	7,300,000	+	+	"				23°	15 ft.	
	690	" " Bay Center	"	6,700,000	+	+	"				22°	22 ft.	
	691	Anchorage Spar Buoy "A" off Gowanus St.	"	2,000,000	+	+	"					23 ft.	

P.S.A.

Ex. 14 - P. 16

(11)

Date 1907	Sample Number	Location	Depth of sample	Bacteria per gram	Presumptive B. Coli .1cc.	Presumptive B. Coli 1cc.	Putrescible	Loss on Ignition	Color	Odor	Water Temp	Water Depth	Remarks.
Oct. 1	692	Anchorage 1200' from Erie Basin	Surf	2,400,000	+	+	Yes					15 ft.	
	693	" 1200' off Gowanus Bay	"	4,900,000	+	+	"					13 ft.	
	694	" 1200' " 39 St. Bklyn	"	4,500,000	+	+	"					17 ft.	
	695	" 1200' " 65 " "	"	4,000,000	+	+	"					20 ft.	
	696	" 1200' " 79 " "	"	3,500,000	+	+	"					19 ft.	
	697	Foot 65 St. Bklyn 100' from Sewer	"	8,000,000	+	+	"					15 ft.	
	698	" 49 " "	"	6,500,000	+	+	"					20 ft.	
Oct. 2	699	Anchorage Bklyn near Buoy "14 N.B."	"	640,000	+	+						15 ft.	
	700	" " " Buoy 5 & off 22 St	"	2,500,000	+	+						15 ft.	
	701	" " " E.S. off 60 St.	"	4,700,000	+	+						18 ft.	
	702	" " " N.S. 39 St.	"	1,700,000	+	+						14 ft.	
	703	" " " N.S. off 49 St	"	2,000,000	+	+						15 ft.	
	704	" " ½ way bet Buoy "14" & Gowanus	"	3,100,000	+	+						11 ft.	
	705	" " N end 500' S Buoy S.A.	"	1,900,000	+	+						15 ft.	

Total 21 Samples in October.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 15.

JAMES D. MAHER,
Commissioner.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 16.

JAMES D. MAHER,
Commissioner.

METROPOLITAN SEWERAGE COMMISSION.

INDEX

OF

STATIONS 1 TO 490.

showing Chart Location and Samples Taken at each Station during 1907

Complainant's Exhibit No. 17.

James D. Maher
Commissioner.

Station No.	Sheet No.	Chart No.	Water Samples Nos.	Mud Samples Nos.
1		7	1	
2	C	7	2	
3		4	3	
4		4	4	
5	B	4	5, 6	
6		4	7	
7		6	8	
8	B	6	9	
9		4	10	
10		4	11	
11		4	12, 13	
12		4	14	
13		4	15, 16, 17, 18, 19, 20, 21, 22, 23	
14		4	24 to 47 incl.	
15		4	48 to 51 incl. 873, 874	698
16	B	4	52, 53	
17		4	54, 55	
18		4	56, 57	12 to 16 incl.
19		4	58, 59	
20		4	72	1
21		4		2
22		4		3
23		4		4
24	B	6		5
25	C	6		6
26		7		7
27		4	60, 61	
28		4	62, 63	
29		4	64, 65	
30	B	4	66, 67	
31		4	68, 69	
32		4	70, 71, 73, 74	
33		6		8
34	B	6		9
35		4		10
36	B	4		11
37	C	7	75, 76, 97-100; 221-224; 538-540 incl. 560-562, 582-586	
38	C	7	79-82; 101-104; 225-228; 291-296, 302-307, 313-318; 324-329; 335-340; 346-351; 357-362; 368-373; 379-384; 390-395; 401-406; 412-417; 423-428; 434-439; 541-544; 563-566; 585-588 incl.	

Comb'n Ex. No. 17. (1)

Station No.	Chart No.	Section No.	Water Samples Nos.	Mud Samples No's
39	C	7	83-86, 105-108, 220-232, 545-546, 567-570, 589-592, 87-89, 109-112, 225-226, 297-299, 308-310, 319-321, 330-332, 341-343, 352-354, 363-365, 374-376, 385-387, 396-398, 407-409, 418-420, 429-431, 440-442, 449-451, 549-551, 571-575, 593-595,	
40	C	7		
41	C	7	90-92, 118-116, 237-239, 552-574, 574-576, 596-698	
42	C	7	93-94, 116-118, 240-242, 300-301, 311-312, 322, 323, 333, 334, 344, 345, 355, 356, 366, 367, 377, 378, 388, 389, 399, 400, 410, 411, 421, 422, 432, 433, 443, 444, 555-557, 577-579, 589-601,	
43	C	7	95-96, 119-121, 243-245, 560, 559, 580, 581, 602, 603	
44	C	6	130-137	17-21
45		6	138-141	22-26
46		2		27
47	C	7	142, 143	
48	B	6	144, 145	
49		5	146-148	
50		5	149-152	
51		5	153-154	
52	B	5	155, 156	
53		5	157, 158	
54		5	159, 160, 161	
55		5	162-163	
56		4	164, 165	
57	C	8	166, 167, 168	28
58		8	169, 170	29, 30, 31, 32, 33, 34
59	C	7	171, 172	35, 36, 37
60		7	173, 174	38, 39, 40, 41, 42, 43
61		7	175, 176	
62	C	8	177, 178	
63		8	179, 180	
64		8	181, 182	
65	D	9	183, 184	
66		9	185, 186	
67	D	10	188, 189	
68	C	6		44-48
69	C	7	189, 190	49-53

Comb's Ex. No. 17. (2)

70		7	191-192		
71	C	7	193-194		
72		7	195-196		
73	B	5	197-198		58-59
74		5	199-200		
75		7	201-202		60-65
76		7	203-204		66-71
77		7	205-206		72-77
78		7	207-208		78-83
79		7	209-210		84-89
80		7	211-212		90-95
81		7	213-214		96-101
82		7	215-216		102-107
83		7	217-218		108-113
84	C	7	219-220		114-119
85		7	246-247		120-125
86		7	248-249		126-130, 152-157
87		7	250-251		158-163
88		7	252-253		164-169
89		7	254-255		150-155
90		7	256-257		156-161
91		7	258-259		162-167
92		7	260-261		168-173
93		7	262-263		174-177
94		5	264-266		178-183
95		5	267 (268)		184-189
96		5	269-270		190-195
97		5	271-272		196-201
98		5	273-274		202-207
99	B	5	275-276		208-213
100		5	277-278		214-219
101		5	279-280		220-225
102		5	281-282		226-231
103		5	283-284		232-237
104		5	285-286		238-243
105	B	6	287-288		244-247
106		4			248, 249
107	B	4	289-290; 871-872		250-254, 697
108		2			255-260
109	A	2			261
110		2			262
111		4			263-268
112		4			269-274
113	B	4			275-280
114		4			281-286
115	B	5			287-292

Comb'd. Ex. No. 17. (3)

116	B	5		288-298
117		5		299-302
118		13		303
119		13		304
120		13		305
121		13		306
122	C	13		307
123		13		308
124		13		309
125		13		310
126		13		311
127		14		312
128	F	14		313
129		14		314
130		10	445, 446, 447	315-320
131		12		321
132		12		322-326
133		12		327
134		12		328-330
135	E	12		331-335
136		12		336-341
137		12		342-347
138		12		348-354
139		12		355-357
140		12		358-362
141		12		363-368
142		11		369-376
143		11		377-381
144	E	11		382-389
145		11		385-391
146		11	776, 777	392-398, 665
147	C	7		399, 399
148		7		400-406
149		2		406
150	A	2		407
151		2		408
152		2		409 410
153		7		411-416
154	C	7		417 421
155		7		422 426
156		7		427-433
157		8	448	
158		8	449	
159	C	8	450	
160		8	451	
161		8	452, 773 774	

Comm'n Ex. No. 17 (4)

PEOPLE OF STATE OF NEW YORK vs. STATE OF NEW JERSEY, 1931

PROFILE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 22nd

212		8		467
213		8		468
214		8		469
215		8		470
216	C	8		471
217		8		472
218		8		473
219		8		474
220		8		475
221		Newton Cr.	765, 766	476, 661
222		"		477
223		"		478
224		"		479
225		"		480
226		"		481
227		8		482
228		8		483
229		8		484
230		8		485
231		8		486
232		8	672, 673	487, 641
233	C	8	670, 671	488
234		8		489, 640
235		8		490
236		8		491
237		8		492
238		7	498-500, 503-505, 625-627, 640-642, 655-657	
239		7	501-503, 514-518, 628-630, 643-645, 658-660	
240	C	7	504-506, 510-513, 631-633, 646-648, 661-663	
241		7	507-509, 522-524, 634-636, 649-651, 664-666	
242		7	510-512, 525-527, 637-639, 652-654, 667-669	
243		5		493
244	B	5		494
245	A	2		495
246	F	14		496
247		12	528, 529	497
248		12	530, 531	498
249		12	532, 533	499 A, 499 B
250	E	12		500
251		12	534, 535	501
252		12	536, 537	502
253		4		503
254		4		504
255	B	4		505
256		4		506
257	A	2		507

Comb's Ex. No. 17. (6)

258		2			508
259		2			509
260	A	2			510
261		2			511
262		2			512
263	B	4			513
264	B	5			514
265		5			515
266		6			516
267		6			517
268		6			518
269		6			519
270	B	6			520
271		6			521
272		6			522
273		6			523
274		6			524
275		6			525
276		6			526
277	B	4			527
278		4			528
279		6			529
280		6			530
281		6			531
282	B	6			532
283		6			533
284		6			534
285	C	6			535
286		13			536
287	C	13			537
288		13			538
289		13			539
290		16			540
291	G	16			541
292		16			542
293		15			543
294		15			544
295	E	15			545
296		15			546
297	F	15			547
298		14			548
299		14			549
300	F	14			550
301		14			551
302		14			552
303		14			553

Comp's. Ex. No. 17. (7)

304	C	13		554
305	G	14		555
306		14		556
307		14		557
308		14		558
309		14		559
310		14		560
311	E	15		561
312		15		562
313		15		563
314		15		564
315	F	15		565
316		15		566
317	D	9		567
318		9		568
319		9		569
320		9		570
321		9		571
322	C	8		572
323		8		573
324		8	E.River opp. Stonetail Slip—1 Ch	
325		2		575
326		2		576
327		2		577
328		2		578
329	A	2		579
330		2		580
331		2		581
332		2		582
333		2		583
334	C	7		584
335		7		585
336		4		586
337		4		587
338		4		588
339		4		589
340		4		590
341		4		591
342		4		592
343	B	4		593
344		4		594
345		4		595
346		4		596
347		4		597
348		4		598
349		4		599

Comp's. Ex. No. 17. (8)

Plaintiff's No.	Chart Section No.	Master Samples Nos.	Blue Samples Nos.
350		6	600
351		6	601
352		6	602
353		6	603
354		6	604
355		6	605
356		6	606
357		6	607
358		6	608
359	B	6	609
360		6	610
361		6	611
362		6	612
363		6	613
364		6	614
365		6	615
366		6	616
367		6	617
368		6	618
369		6	619
370	C	7	604
371		6	605, 606
372		6	607, 608
373		6	609, 610
374	B	6	611, 668 670
375	C	6	612, 866, 867
376	B	6	613, 614
377		4	615, 616
378	B	4	617, 618
379		4	619, 620
380		4	621, 622
381		2	623, 624
382		2	620-622
383		2	623
384		2	624
385		2	625
386		2	626
387		2	627
388	A	2	628
389		2	629
390		2	630
391		2	631
392		2	632
393		2	633
394		2	634
395		2	635

Station No.	Chart No.	Sample No.	Water Samples Nos.	Mud Samples Nos
396		2		636
397	B	2		637
398		2		638
399		2		639
400	C	8		640
401		7		643
402	C	7		644
403		7		645
404	B	6		646
405		6		647
406		5		648
407	A	5	690, 691	649
408		5	692, 693	650
409	B	6	694, 695, 696	651
410	C	6	697, 698	652
411		5	699, 700	653
412		5	701-703, 715-717	654
413	B	5	704-706, 718-720	
414		5	707-709, 721-723	
415		5	710-712, 724-726	
416		5	713, 714, 722, 728	655
417		11	729 730, 733, 738	656
418	E	11	731-733, 739-741	657
419		11	734-736, 742-744	658
420		4	745, 746, 754, 755	659
421	B	4	747-749; 756-759	
422		4	750-753, 760-762	
423		Newtons Cr	763, 764	660
424		"	767, 768	661
425		"	775	
426		11	778-780	666
427	E	11	781-783	667
428		11	784-786	668
429		12	787-788	
430	E	12	789-790	669
431		12	791 793	670
432		13	794-797	
433	C	9	798-801	
434		Newark Bay	802-804, 827-829	671
435		"	805-807, 824-826	672
436		"	808-810, 821-823	673
437		"	811-813, 818-820	674
438		"	814 815, 816-817	675
439		15	830 831, 846, 847	
440	E	15	832 835, 844-845	676
441		16	833-834, 850-852	677

Com'rs Ex. No. 17.

Station No.	Chart No.	Section No.	Bottom Sample Nos.	Mud Sample Nos.
442	G	16	837 - 841, 853 - 855	678
443	G	16	842, 843, 856, 857	679
444				680 - 682
445		Newark Bay		683
446				684
447			858, 859	685
448		Gowanus Creek	860, 861	686
449			862, 863	687
450			864, 865	688
451	B	6		691
452		6		692
453		6		693
454		4		694
455	B	4		695
456		4		696
457	B	6		699
458	C	4		700
459		4		701
460		6		702
461	C	6		703
462		6		704
463		6		705
464		Hackensack R.	875, 876	
465			877	
466			878	
467			879	
468			880	
469			881 - 882	
470			883	
471			886 - 886	
472			887, 888	
473			889	
474			890	
475			891, 892	
476			893, 894	
477			895, 896	
478			897, 898	
479			899	
480			900	
481			901, 902	
482			903	
483			908 - 906	
484			907	
485		East River Flats East	908 - 931	
486			932	
487			933	

1878 1879 1880			934 935 936		

3216

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 18.

JAMES D. MAHER,
Commissioner.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 20.

JAMES D. MAHER,
Commissioner.

Complainants' Exhibit No. 20.
James D. Nichols,
Commissioner.

DATA

RELATING TO WATER SAMPLES Nos. 1 to 931
FROM NEW YORK BAY & VICINITY
EXAMINED BY THE METROPOLITAN SEWERAGE COMMISSION, 1907
SHEETS 1 to 23 incl.

(1)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Dextrose Broth 48 hrs Presumptive B Coli I.C.C.	Dextrose Broth 48 hrs B Coli I.C.C.	Turbidity	Color	Chlorine Pts. per mil.	Tide	Wind	Temp of Water	Location & Remarks
Jan 4-07													
7:32	1	1	1					30	10400	Flood		7°6	N. River 200' SE Pier 12
last P. 10:30 a.m.	1	2	5					25	7800	Ebb			" " " End " "
last 12:25 P.	1	3	10						13100	First of flow	Light N.		150' S.W. End 49 St. Sewer B'klyn
last 11:15		4	10						13600	1st Ebb	N.N.W. 7-8 m	4½°C	50' off Pier 53 B'klyn
12		5	10						13000	Ebb	" " " "	"	½ but Atlantic Club & Edison
1	4	6	20						12600	"	" " " "	"	" " " " "
2		7 (3)	10						11800	"	" " " "	"	Anchorage of A.B. Club
last 10:30 a.m.		8	10					17½	1100	Flood	N.W. 8m	3	"
11:30 P.M.	2	9	10					17½	12200	1st Ebb	" "	3	200 yds E. Can buoy #14
12:30	2	10	10					30	11600	Flood	N.W. Slight		Mouth 49 St Sewer B'klyn
12:15 P.M.		11	10					25	12000	"	" "	6	75' off " "
7 A.M. Jan 5-07	3	12 (4)	1'	290000					9200	Slack / low	N.W. mod	4½°C	49 St. B'klyn 100' from
8:50		13	20'	40000					10400	"	" "	12°	sewer outlet
9		14 (5)	5'	16000					10200	1st Flood	" "	8°	Piles bet. 49 & 52 St.
9 A.M.		15 (6)	2'	390000				25	9200	Ebb	Calm	4°	" " " " "
11:15	9	16	10'	19000				17½	10000	"	"	13°	" " " " "
11:15		17	20	4500				17½	10600	"	"	4°	" " " " "
1:10 P.M.		18	2'	60000				30	8400	"	"	3½°	" " " " "
1:15		19	10'	12500				17½	10200	"	"	13°	" " " " "
1:30		20	20'	6500				15	10600	"	"	12°	" " " " "
3:45		21	2'	380000				25	9200	Flood	"	13°	" " " " "
3:25		22	10'	280000				17½	10200	"	"	12°	Affected by overflow from dredge
3:25		23	20	150000				17½	10800	"	"	11°	100' away
Jan 26 9:20 a.m.	24	24	2'	8200	acid +			16	13000	Ebb	N.W. Slight	1°	52 St. B'klyn 500' off end Pier
		25 (7)	10'	5500	" +			15	13200				
9:45		26	20'	3000	" -			15	13000				
11		27	2'	7500	" +			17	12200	Ebb		1°	" " " " " "
		28	10'	5000	" +			15	12600				
		29	20'	2500	" +			18	12400				
3:15 P.M.		30	2'	7500	" +			25	12000	Slack		1°	" " " " " "
		31	10'	6000	" +			23	12200				
		32	20'	3000	" +			17	12200				
4:15		33	2'	7500	" +			17	12100	Flood		1°	" " " " " "
		34	10'	5500	" +			20	12200				
		35	20'	3500	" +			18	12600				
9:15		36	2'	8500	" +			18	12200	Slack		1°	" " " " " "
		37	10'	5500	" -			17	12600				
11 A.M.		38	20'	4000	" +			17	12200				
		39	2'	7000	" +			15	12500	Ebb	N.W. 4 miles	1°	" " " " " "
		40	10'	5500	" +			17	12500				
		41	20'	2500	" -			15	12400				
Total Samples	41												

Ex. 20 - P. 1.

(2)

Date and Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per c.c.	Dextrose Broth Ferm. Presumptive I.C.C.	Dextrose Broth Ferm. B. Coli I.C.C.	Turbidity	Color	Chlorine Parts per mill.	Tide	Wind	Temp. of Water	Location & Remarks
Jan 27 10 AM		62	2'	6500	Acid +			23	12420	Slack			43 N. Bklyn 500' off End Pier.
		63	10'	8500	" +			17	12300				
		64	20'	8500	" +			18	12100				
1 PM		65	2'	8500	" +			18	12000	Flood		37°6	" " "
		66	10'	8500	" +			17	12060				
		67	20'	5000	" +			18	12000				
Jan 4 8 AM		68 (47)	2'	25000	" +	Acid +	40		11960	Flood	N. Snow	36°	43 N. Bklyn 3 K. End Pier
8 AM	12	69	10'	18000	" +	" +	40		11810			36°	" "
		70	20'	14000	" +	" -	30		12360			35°	
8 AM		71	30'	11900	" +	" -	50		11970			35°	75 way bet. 43 & 52 St. Piers.
1 PM		72 (48)	Surf.	13000	" +	Acid +	20		11970	Slack		36°	
		73	2'	16000	" +	" +	30		12170			35°	3/4 " " " " " "
1 PM		74 (71)	Surf. 17'	12000	" +	" +	35		12170	1st Ebb.		35°	
		75	2'	9000	" +	" -	20		12030			35°	52 St End Pier
1 PM		76 (81)	Surf. 16'	28000	" +	" +	30		12170	Ebb		36°	
		77	2'	14000	" +	" +	50		12290			36°	Piles bet 43 & 52 St
10 AM		78 (28)	Surf. 15'	79000	" +	" -	25		12340	Ebb			
		79	2'	47000	" +	Acid +	20		13620				
Jan 18		80	10'	47000			20	10	13800	Flood	At 12 miles	42°	Bell buoy anchorage off 21 Pier
1910 PM	15	60 (17)	1'	160000			22	20	14700			42°	
		61	Surf. 25'	9000			18	10	12300	Flood	N	42°	75 way from shore & Edison Chimney
2 PM		62 (67)	1'	10000			20	10	13790			42°	
		63	20'	6000			15	5	13730			42°	3/4 " " " " " "
2 PM		64 (83)	1'	7500			20	10	13790			43°	
		65	20'	5500			20	10	13800	Flood	N.	43°	Op. Edison Chimney (anchorage)
1 PM		66 (90)	1'	8100			20	10	14340			43°	
		67	20'	4000			22	9	12310	Flood	N.	43°	Op. 52 St. "
1 PM		68 (91)	1'	9500			20	9	12600			43°	
		69	10'	7000			20	10	13100	Flood	N	43°	Op. Governors Bay buoy 14 "
1 PM		70 (94)	1'	21000			20	12	13800			43°	
		71	Surf. 20'	13500			20	30	6800	Flood	N	43°	Piles bet 43 & 52 Sts.
1 PM		72 (10)	Surf.	6750			100	10	13080	1st Ebb	N	43°	Op. Governors Bay buoy 14 Anchorage
1 PM		73 (24)	1'	18000			20	10	12730			43°	
10 AM		74	15'	13000			20	15	13470	Flood	N. mod	43°	N River 100' from Pier "42"
1 PM	22	75 (40)	1'	6350			17	25	10250	1st - 2 hrs			
		76	20'	5200			15	12	10680				
		77	40'	4050			20	12	10680				
		78	60'	3800			30	15	12430	Flood	N	43°	" " Sea " " "
Jan 29		79 (96)	1'	5850			17		9450				
		80	20'	5100			15	13	11730				
		81	40'	4550			25	12	12490				
		82	60'	2850			150	25	12830				

Date & Hour	No Sample taken	Serial Numbers	Depth of sample	Bacteria per c.c.	Presumptive B.C.	B. Coli B.C.	Turbidity	Color	Chlorine P/a per m.	Tide	Wind	Temp of Water	Location & Remarks.
May 30													
8.30 P.M.		83 (a)	1'	4550			20	17	5400	Flood	N.	72° C	N River 1/4 way across
		84	25'	3800			15	12	10970				
		85	50'	3400			100	50	13130				
		86	58'	3500									
9 "		87 (a)	1'	3800			20	13	8960	Flood	N.	72°	" " midstream
		88	25'	3395			15	12	10570				
		89	45'	2600			30	12	10470				
9.30 "		90 (a)	1'	3400			15	13	10130	Flood	N.	75°	" " 1/4 way across
		91	25'	2825			15	10	11165				
		92	50'	2170			70	15	13330				
9.45 "		93 (a)	1'	4220			20	17	10300	Flood	N.	75°	" " 500' from Jersey Coast R.R.
		94	25'	4050			20	17	10800				
10 "		95 (a)	1'	4850			30	20	9750	Flood	N.	65°	" " 100' " " " " "
		96	30'	4970			30	17	11610				
Feb 31													
9.45 A.M.	85	97 (a)	1'	7960			15	15	10630	Ebb	W. 8 miles	0°	" " 100' " Pier "A"
		98	25'	6570			15	15	10370			69°	
		99	45'	4370			30	10	11384			75°	
		100	60'	3890			60	15	12490				" " 500' " " "
11 "		101 (a)	1'	6250			20	15	10370	Ebb	W.		
		102	25'	4870			15	12	10830				
		103	45'	3920			20	10	11310				
		104	50'	3410			30	10	10320				
11.15 "		105 (a)	1'	3890			15	12	9700	Ebb	W.		" " 1/4 way across
		106	25'	3500			10	15	10360				
		107	40'	3400			15	15	11310				
		108	58'	3450			15	12	10330				
11.45 "		109 (a)	1'	3600			30	20	9700	Ebb	W.		" " Midstream
		110	30'	3300			20	17	10470				
		111	45'	3201			15	12	11396				
		112	Bot. 65'	3320									
11.30 "		113 (a)	1'	3600			20	20	9700	Ebb	W.		" " 1/4 way across
		114	25'	3304			25	17	10960				
		115	Bot. 45'	3300			25	12	11670				
11.45 "		116 (a)	1'	1900			30	20	9700	Ebb	W.		" " 500' from N.J.C.R.R. bottom stirred up
		117	25'	3300			45	25	10330				
		118	Bot. 35'	3800			50	20	10380				
1 "		119 (a)	1'	3950			20	20	9300	Ebb	W.		" " 100' from N.J.C.R.R. bottom stirred up
		120	20'	3690			70	26	10300				
Feb 32		121	Bot. 23'	6830			45	30	10470				
11.00	30	122 (a)	1'	6450			15	10	11390	Ebb	N.W.	75°	Piles of 51 St. B'klyn.
		123	18'	3400			30	15	10790			74°	

(4)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per cc	Presumptive 1cc	B Coli 1cc	Turbidity	Color	Chlorine Parts per M.	Tide	Wind	Temp of Water	Location & Remarks.
Feb 2/ Cont													
11:30 a m		124 (20)	1'	5600			20	12	11650	Ebb	N.W.		Piles of St St. B'klyn
		125	15'	3300			20	12	11810				
12 M.		126	1'	7100			20	12	11480				" " " " "
		127	15'	4350			20	10	11810				
1 P.M		128	1'	6450			20	12	11700				" " " " "
		129	15'	5500			18	12	11650				
1:40 "		130 (21)	1'	125000			50	30	11130	Mt Flood	N.W.	3/4°	Gowanus Canal Ft Court St.
		131	10'	115000			40	30	10630			1°	
2 "		132	1'	160000			55	30	10200				" " " " "
		133	10'	100000			30	25	10800				
2:30 "		134	1'	190000			40	30	10460				" " " " "
		135	10'	130000			30	25	10800				
2:40 "		136	1'	160000			33	22	10300				" " " " "
		137	10'	105000			30	20	10970				
3 "		138 (22)	1'	240000			30	30	9960	Flood	N.W.	3/4°	" " 500' below Hom. Av. Br.
		139	15'	185000			40	30	11470			1°	
3:30 "		140	1'	320000			200	50	9970				" " " " " " "
Feb 28		141	15'	158000			40	20	12820				
9:10 a m	24	142 (47)	1'	3800			30	10	11400	Ebb	S.	0°	Midway bet Ellis & Liberty Isds.
		143	bot 10'	6850			150	20	12180			1/4°	bottom stirred up.
11:20 "		144 (48)	1'	3200			20	10	11480	"	S.	0°	200' S. of Liberty Isd.
		145	10'	2100			20	10	12660			1/4°	
11:50 "		146 (49)	1'	1140			10	9	11980	"	S.	0°	500' s. Robbins Reef Light
		147	10'	950			10	8	12160				
		148	30'	550			10	75	12830			1/4°	
12:30 P.M.		149 (50)	1'	2850			10	7.5	11650	"	S.	0°	2000' off St. George S.I
		150	10'	2300			10	8	11980				
		151	20'	1900			12	8	12330			1/4°	" " " " " "
		152	40'	1600			10	8	12490			1/2°	
1 "		153 (51)	1'	4850			12	10	11310	"	S.	0°	Kill Von Kull 500' off St. George
		154	20'	2100			18	11	11650			1/4°	
1:15 "		155 (52)	1'	5100			18	11	11400	"	S.	0°	" " " 500' off B20 yards
		156	20'	2300			20	11	11480			1/2°	
1:25 "		157 (53)	1'	5200			18	15	10800	"	S.	0°	" " " 500' off W. Brighton
		158	20'	3100			18	15	11480			1/4°	
1:40 "		159 (54)	1'	5100			18	15	11140	"	S.	1/4°	" " " E End Constable Pl.
		160	10'	3700			18	16	11000				
		161	30'	2650			15	16	11140				
2 "		162 (55)	1'	6050			10	15	11140	"	S.	1/4°	" " " W. " " "
		163	10'	4850			10	15	11140				
2:25		164 (56)	1'	2650			10	14	11980	"	S.	1/4°	3000' W. Robbins Reef Light
		165	20'	1900			12	13	11980				Opp Gowanus Bay.
Total Feb.	118												

Ex. 20. p. 4.

(5)

Date & Hour	No Samples Taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Lactose Bile 24 hrs Presumptive 1 C.C.	Lactose Bile 24 hrs B. Coli. 1 C.C.	Turbidity	Color	Chlorine Grs per gal	Tide	Wind	Temp. of Water	Location & Remarks
Mar 2, 1907													
9 A.M.	3	166 (51)	1'	4000			40	15	11650	Flood	N.W.	21° C	E. River End of Pier 24 St.
		167	20'	3200			20	17	11810				
		168	Bot 28'	2450			60	20	11810				
10 A.M.		169 (52)	1'	8500			40	20	11980	Flood	N.W.	21° C.	" " ½ to " " "
		170	Bot 20'	7600			50	20	11980				
1.30 P.M.		171 (53)	1'	670			50	17	11140	Flood	N. 15 miles	1°	Ellis Isd. S. Slip
		172	10'	500			200	15	11980			1°	
2.30 P.M.		173 (54)	1'	300			20	15	11650	Flood	N. 15 miles	1½°	Liberty Isd E. dock
		174	10'	500			40	15	11980			1½°	
Mar 7 11.45 A.M.	14	175 (55)	1'	1000	+0% Quid +		20	15	11140	Flood	N.	1°	E. River midstream opp Pier 8
		176	20'	950	25 " +		30	15	11140			1½°	
12 M.		177 (56)	1'	1050	30 " +		30	15	11140	"	N.	1°	" " 500' off Jay St. B'klyn
		178	20'	1050	10 " —		30	15	11660			1°	
12.40 P.M.		179 (57)	1'	1300	40 " +		40	15	11480	"	N.	1°	" " midstream opp 40 St.
		180	20'	1900	10 " —		50	15	11300			3°	
1.30 P.M.		181 (58)	1'	1550	10 " —		40	15	11470	"	N.	1°	" " " opp 38 St.
		182	20'	1200	10 " —		20	15	11470			1°	
2.15 P.M.		183 (59)	1'	3200	25 " +		20	15	11480	"	N.	1°	" " 200' off 28 St.
		184	20'	1400	30 " +		20	15	11480			1°	
3.00 P.M.		185 (60)	1'	1650	10 " —		15	15	11300	"	N	1°	" " midstream opp 92 St.
		186	20'	1600	20 " +		30	15	11500			1°	
4.00 P.M.		187 (61)	1'	1850	30 " +		30	15	11300	"	N	1°	" " " opp Wards Isd dock
		188	20'	1200	25 " +		10	15	11300			1°	
Mar 12 10.15 A.M.	12	189 (62)	1'	4350			25	10	8780	Ebb	E Mod	1°	Bayonne, S.S. Black Tom
		190	15'	3300			30	12	8950			1½°	
10.30 A.M.		191 (63)	1'	4750			25	10	11140	"	E.	1°	" " " " Gr. Elev
		192	15'	4150			20	12	11480			1½°	
10.45 A.M.		193 (64)	1'	3800			20	10	11650	"	E	1°	" " " opp 5 Shore
		194	15'	2950			20	10	11810			1½°	
11.15 A.M.		195 (65)	1'	6450			20	12	11650	"	E	1°	" outer end " "
		196	15'	4350			20	10	11810			1½°	
12.30 P.M.		197 (66)	1'	4750			20	12	11310	"	E	1°	150 Van Nest W. End Coal Pt.
		198	6'	5700			25	16	10970			1½°	
1.30 P.M.		199 (67)	1'	6350			25	16	13330	"	E	1°	Bayonne N. Robbins Reef opp B.A.P.
		200	20'	2650			25	12	12150			1½°	
Mar 15 10.30 A.M.	8	201 (74)	1'	6350			12	20	11310	Flood	N.W. Strong	1°	Bet. Ellis & Liberty 400 yds from Ellis
		202	8'	2600			30	16	11810			1½°	
11.30 A.M.		203 (75)	1'	9350			30	12	11480	" HW	NW	1°	" " " " ⅓ distance from "
		204	5'	7400			30	15	11980			1½°	
12.45 P.M.		205 (77)	1'	6350			18	17	12150	1 hr Ebb.	N.W.	1°	" " " " ⅔ " " "
		206	5'	4750			35	17	11980			1½°	

Ex. 20. P. 5.

(6)

Date & Hour.	No. Samples taken	Serial Numbers.	Depth of Sample	Bacteria per C.C.	Presumptive B. Coli 1 C.C.	B. Coli 10 C.C.	Turbidity	Color.	Chlorine M/1 per ml	Tide	Wind	Temp of Water.	Location & Remarks.
Nov 15 Cont 1:45 P.M.		207 (via)	bot 6' 1'	4000			45	20	12660	Ebb.	N.W. Strong	1°	Bet. Ellis & Liberty 200 yds from Liberty
1:50 "		208	5'	5800			60	12	12660			1½°	
Nov 18 10:10 a.m.	12	209 (via)	bot. 7' 1'	5300			12	17	7430	Flood	E. 6 miles	2½°	Off Jersey back of Ellis Id.
" "		210	6'	4250			12	15	7980				
" "		211 (via)	bot. 8' 1'	3200			11	15	7600	"	E. "	2½°	" " nearer Liberty Id
		212	6'	2450			13	12	7910				
12:30 P.M.		213 (via)	1'	3200			12	15	7600	"	S.W.	2½°	" " ¼ way from Ellis "
" "		214	bot 7½ 6½	2650			20	17	7760				
" "		215 (via)	1'	3300			15	12	7600	1st Ebb.	"	2½°	" " nearer " "
		216	(6½) 6'	3200			50	17	7600				
1:34 "		217 (via)	1'	1900			15	15	7600	Ebb.	"	2½°	" " ½ off " "
		218	(6½) 6'	1150			80	17	8270				
2:35 "		219 (via)	1	1600			15	12	7600	Ebb.	"	2½°	Further off Shore
Nov 21		220	bot. 8	750			20	15	8100				
8:45 a.m.	25	221 (via)	1	3900			20	17	2870	← Ebb.	N.W. 10 miles	1°	N. River 100' from Pier a.
		222	(53) 20	3700			10	15	6920				
		223	40	2650			20	15	6920				
		224	50	2800			20	17	7680			2°	
11:10 a.m.		225 (via)	1	4000			18	17	2870	"	" " "	1°	" " 500' " " "
		226	bot. 55 20	2650			10	12	6070				
		227	40	2450			13	15	6920				
		228	50	1780			15	12	7430			2°	
11:25 "		229 (via)	1	3200			20	17	3380	"	" " "	1°	" " ¾ way across
		230	20	3200			10	15	5570				
		231	bot. 55 40	2100			12	15	6920				
		232	50	1900			15	15	7430			2°	
11:50 "		233 (via)	1	2850			20	17	2870	"	" " "	1°	" " midstream
		234	20	2450			15	15	5230				
		235	bot 46' 40	1900			30	12	9790				
		236	45	1150			60	15	9960			2°	
2:10 "		237 (via)	1	3700			30	20	3040	"	" " "	1½°	" " ¾ way across
		238	20	2650			30	17	4390				
		239	bot. 35' 30	1900			40	15	6920			2°	
2:25 "		240 (via)	1	3700			30	17	2870	"	" " "	1½°	" " 500' from N.J. C.R.R.
		241	20	3400			40	17	4220				
		242	bot. 25	2650			40	15	5230			2°	
11:45 "		243 (via)	1	4450			30	15	3590	Last of Ebb	" " "	1¾°	" " 100' " " "
		244	20	4250			30	17	4560				
11:50 "		245	bot. 28	6350.			30	12	7930.			1¾°	

Hudson River in freshet flow

Ex. 20 p. 6.

(7)

Date & Hour	No Samples taken	Serial Numbers	Depth of Sample	Bacteria per C C	Presumptive B. Coli 1 C C	B. Coli 1 C C	Turbidity	Color	Chlorine Pts / 100 cc	Tide	Wind	Temp of Water	Location & Remarks
Apr 11/07 1230 P.M.	8	246 (11)	Bot 4' 1	10600				17	5230	Ebb.	S.E. 7 miles	3°	Off Jersey 1000' N. Ellis Isld
40 "		247	8	8500				13	5310			2½°	
1.30 "		248 (12)	Bot 12' 1	5000				17	4730	"	"	3 °	" " 200' E of above
35 "		249	10	5000				20	5570			2½°	
2.30 "		250 (13)	1	1700				17	3040	"	"	3 °	" " " " " " last
33 "		251	Bot 17	9250	Bot shirred up			15	4220			2½°	
2.35 "		252 (14)	1	1800				17	3040	Last P. Ebb	"	3 °	" " " " " " last
40 "		253	Bot. 20	4150	" " "			17	4560			2½°	
April 11/07 11.00 A.M.	10	254 (1)	1	1050				Broken in	Transit	First P. Eb.	N. 20 miles	3½°	Off Bayonne 100' N. Blk. Pier
1.05 "		255	Bot. 10	1800	" " " 51		30	20	5060			3½°	
1.00 P.M		256 (20)	Bot 7½' 1	950			50	20	4730	Ebb	" " "	"	" " 1000' N. of last
.05 "		257	7	1400			70	Broken in	Transit			"	
1.40 "		258 (21)	Bot 6½' 1	1050			40	" "	"	"	" " "	"	" " W. of Liberty Isld.
.45 "		259	6	2750			100	20	4890			"	
2.10 "		260 (22)	Bot 7 1	2950			30	17	4730	"	" Miles	"	" " W. of Ellis Isld.
.15 "		261	6	3500			70	20	5230			"	
2.25 "		262 (23)	Bot 7½ 1	1800			70	17	4730	"	" 7 "	"	" Communipaw
.30 "		263	7	2300			70	20	5400			"	
Apr 8 11.45 A.M	11	264	Bot 9 1	340	Presence or surface of water		10	20	6080	Flood	N.W.	7°	" Jersey bet. Liberty Isld & Ellis Isld
48 "		265	8	300	other signs & scum visible		15	15	6080			7½°	
50 "		266	Bot 12 Surf.	600	more or less oil over whole surface		20	15	6080	"	N.W.	" " " " " " " "	
1.25 P.M		267	1	1000			20	15	6240			7½°	" " off Bay View Cemetery
30 "		268	10	1320			20	15	6920			7 °	
2.30 "		269	Bot 12 1	900			10	17	6240	"	N.W.	7 °	" bet. last & Pa. R.R.
35 "		270	10	720			40	17	6920			7½°	
3.00 "		271	Bot 12 1	1240			15	15	6080	Ebb	N.W.	7 °	N. of Pa. R.R. Docks
05 "		272	10	900			10	12	7260			7½°	
4.00 "		273	Bot 12 1	740			10	15	5910	"	N.W.	7 °	" and " " " "
.15 "		274	10	400			10	12	7090			7½°	
Apr 11/07 9.30 A.M.	12	275	Bot 6½ 1	2370			15	12	9280	First Ebb	N.W. 20 miles	4½°	Bayonne 100's " " "
35 "		276	8	2860			15	10	9620				
12.15 P.M		277	1	1380			15	12	9450	Ebb.	N.W.	"	" S. toward Constable Pt
20 "		278	Bot 7	2320			70	20	9450				
1.35 "		279	1	3080			20	12	8950	"	N 10 miles	"	" S " " "
40 "		280	Bot 7	3190			20	12	9120				
2.35 "		281	1	3540			25	15	6580	"	N. 5 "	"	" off " " to N.
40 "		282	Bot 7	6890			20	15	7430				
3.15 "		283	1	8980			15	15	7260	Flood	N.	"	" " " " " to E.
20 "		284	Bot. 8	3170			30	15	8940				
4.30 "		285	1	2220			25	12	7430	"	N	"	" " " " " Kill Von Kull
35 "		286	Bot. 15	3080			30	12	8430				
Apr 12/07 1.10 P.M.	2	287	Bot 8 1	4550			15	10	6240	Ebb	NW 10 miles	5½°	Anchorage off Governors Isld.
.15 "		288	17	2750			15	12	8440				

Ex. 20. P. 7.

K. J. K.

(8)

Date & Hour	No. Samples Taken	Serial Numbers	Depth Of Sample	Bacteria Per C.C.	Presumptive 1 C.C.	B Coli 1 C.C.	Turbidity	Color	Chlorine Mg. per Ltr.	Tide	Wind	Temp. of Water	Location & Remarks
Apr 22 1:00 PM	2	289	Surface 1'	60000			30	15	6580			12.8° C.	100' off 65 St Sewer B'klyn.
5:05 "		290	15'	18000			20	15	7930				
	77	291	Surf.				2	11	8550				Hudson River
Apr 23 10:00 AM		292	10'				2	5	9450				
		293	20'				2	4	11800				500' off Battery
		294	30'				1	3	11600				
		295	48'				1	2	14400				A
		296	Bottom				2	4	14050				
		297	Surface				2	14	7600				Midstream B
		298	20				3	15	12200				
		299	Bottom				2	7	14150				500' off Communipaw Coal Co.
		300	Surf				2	5	8000				dock Jersey City C
		301	20 ft Bottom				2	9	11700				
11:00 A.M.		302					7	2	7650				A
		303					6	2	8650				
		304					4	2	9850				500' off Battery
		305					2	2	12800				
		306					3	2	14000				
		307					4	2	14500				
		308					10	2	7150				B
		309					12	2	8400				Midstream
		310					4	2	14500				
		311					6	2	7600				C
		312					4	3	12500				
12:00 M.		313					10	2	7000				
		314					12	2	8500				
		315					8	2	10050				A
		316					6	2	10450				
		317					6	2	13700				
		318					2	3	14500				
		319					2	10	7050				
		320					2	12	8950				B
		321					3	10	13650				
		322					2	8	7700				
		323					3	12	10700				C
1:30 P.M.		324					3	12	8252				
		325					3	10	9000				
		326					2	6	10750				A
		327					2	4	12350				
		328					2	8	11350				
		329					2	2	14000				

(9)

Date & Hour	No Samples Taken	Serial Numbers	Depth of Sample	Bacteria Per c.c.	B. Coli /CC		Turbidity	Color	Chlorine p.p.m. per cent	Tide	Wind	Temp. of Water	Location & Remarks
		330					2	10	6600				
		331					2	4	9900				B
		332					2	4	13350				
		333					2	15	7500				
		334					2	8	9800				C
1:40 PM		335					2	12	6300				
		336					3	10	7300				
		337					3	5	11800				A
		338					2	5	13500				
		339					2	4	12250				
		340					2	4	12600				
		341					4	12	6300				
		342					2	12	9450				B
		343					2	8	13100				
		344					3	10	6300				
		345					3	14	10600				C
2:20 PM		346					4	10	7100				
		347					2	10	8400				
		348					2	8	10000				A
		349					3	8	11300				
		350					3	10	11700				
		351					3	8	14400				
		352					3	0	6850				
		353					3	6	9000				B
		354					3	0	11650				
		355					2	4	7050				
		356					2	6	7000				C
4:40 PM		357					3	10	8300				
		358					3	15	9300				
		359					2	8	9650				A
		360					2	2	11950				
		361					2	2	12700				
		362					2	5	13650				
		363					8	15	8100				
		364					2	2	9850				B
		365					2	2	15700				
		366					4	8	8250				C
7:30 AM		367					2	2	8150				
		368					2	23	10250				A
	77	369					8	80	10995				

Ex 20 - p 9

334

(10)

Date & Hour	No. Samples Taken	Serial numbers	Depth of Sample	Bacteria Per C.C.	Presumptive B. Coli. 1 C.C.	B. Coli. 1 C.C.	Turbidity	Color	Chlorine Pts. per mil	Tide	Wind	Temp. of water	Location & Remarks
10:45 Sunset		370	25'				3	17	10550				
		371	30'				2	15	11850				A
		372	90'				3	15	12650				
		373	Bottom				2	5	12850				
		374					2	5	10350				
		375					2	5	10600				B
		376					2	10	12900				
		377					3	8	9800				C
		378					3	12	11800				
11:00 P.M.		379					3	15	9800				
		380					2	20	10200				
		381					2	6	11000				A
		382					2	9	12500				
		383					2	6	12600				
		384					2	4	13000				
		385					1	7	9550				
		386					2	5	11500				B
		387					2	5	12500				
		388					25	15	9900				C
		389					2	15	10800				
12:00 M.		390					2	10	9400				
		391					2	5	9550				
		392					3	14	11150				A
		393					2	3	10300				
		394					3	12	11800				
		395					2	3	12150				
		396					2	4	8900				
		397					4	18	10850				B
		398					15	3	12450				
		399					2	3	9900				C
		400					1	3	10250				
1:00 P.M.		401					2	18	8350				
		402					2	5	8900				
		403					2	10	9950				A
		404					1	3	10600				
		405					2	4	11350				
		406					2	18	11300				
		407					8	30	8400				B
		408					3	12	9150				
		409					2	6	11950				

(11)

Date & Hour	No Samples Taken	Serial Numbers	Depth Of Sample	Bacteria per C.C.	Presumptive 1 C.C.	B Coli 1 C.C.	Turbidity	Color	Chlorine	Tide	Wind	Temp. of Water	Location & Remarks
[illegible] Cont.		410					8	10	8700				C
		411					4	10	9750				
2.00 P.M.		412					3	14	8000		"		
		413					2	8	8350				A
		414					8	15	8950				
		415					2	4	10850				
		416					2	3	10400				
		417					4	15	11550				
		418					2	18	7800				B
		419					2	15	9350				
		420					1	3	11900				
		421					2	8	8050				C
		422					3	10	9300				
3.00 P.M.		423					1	5	8250				
		424					2	10	8850				A
		425					2	8	9800				
		426					1	3	11750				
		427					3	5	11750				
		428					10	15	11850				
		429					8	14	8200				B
		430					8	15	9150				
		431					2	10	11500				C
		432					2	4	8850				
		433					2	5	10200				
4.30 P.M.		434					3	3	8400				
		435					3	5	9050				A
		436					3	10	10100				
		437					8	15	10700				
		438					2	10	10950				
		439					4	15	12650				
		440					1	8	8650				B
		441					3	20	9500				
		442					15	20	12100				C
		443					4	10	8850				
		444					2	15	9700				Spuyten Duyvil E. End Pier Draw
		445 (rm)	1'				35	20	2800				
		446	10'				40	20	2800				
9.23 Jan P.M. 1.5 P.M.		447	20'				40	20	13500		N.W. Strong		E. River Slip foot 6 St. Sewer
		448 (rm)	Surf.				40	25	3300				" " 100' off " " "
		449 (rm)	"				10	20	10900				" " midstream " " "
		450 (rm)	"				5	12	14000				100' off Bklyn Shore opp " "
		451 (rm)	"				5	12	12900				

(12)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Lactose Bile 48 hrs. Presumptive 1/6	Lactose Bile 48 hrs. B. Coli 1/6	Turbidity	Color	Chlorine Pts per M	Tide	Wind	Temp of Water	Location & Remarks.
May 28													
5 P.M.		452 (1st)	Surf.				50	40	11800				Newtown Cr under lower Drawbridge
5:15 "		453 (1st)	"				45	40	11300				100' above " "
1st b		454 (2nd)	"				Brewery wants low high in sugar to determine Cl. Directly		11000	Slack high	S.W. mod		100' at Meeker Av Br
Nov 11 at		455 (2nd)											100' at Greenpoint Ave
11 a m	42	456 (2nd)	1'	1150	40% acid +	25% acid +	15	12	10980	Last of flood	S.E. mod	13½° C	A 1000' from Jersey shore
		457	bot. 10'	980	40 " +	15 " +	15	12	13900				
11:20 "		458 (2nd)	1'	1560	25 " +	25 " +	3	12	12200	Slack	1'	14°	B near Robbins Reef
		459	bot 10'	1120	40 " +	25 " +	3	10	13600				
11:45 "		460 (2nd)	1'	940	30 " +	30 " +	6	12	11500	Slack		13½°	C Mid-Channel
		461	bot. 47' 20'	670	25 " +	25 " +	3	10	12800				
		462	45'	460	25 " +	15 " +	3	10	14500				
12:10 P.M.		463 (2nd)	1'	1400	40 " +	40 " +	6	10	11500	1st of Ebb		13½°	D Anchorage
		464	bot. 20'	820	25 " +	25 " +	20	10	13800				
12:30 "		465 (2nd)	1'	2000	50 " +	40 " +	18	20	11400	Ebb		13¼°	E Bay Ridge Channel
		466	20'	1340	40 " +	25 " +	5	15	11800				
		467	bot 35'	690	40 " +	25 " +	20	10	13600				
12:45 "		468 (2nd)	bot. 12 1'	4240	70 " +	50 " +	18	15	11300	"		14°	F 100' from Bklyn shore
		469	10'	2400	60 " +	40 " +	18	12	11600				
1:05 "		470 (2nd)	1'	1040	25 " +	25 " +	18	10	10900	"		15°	A
		471	bot. 10'	710	25 " +	15 " 0	12	10	11500				
1:25 "		472 (2nd)	1'	1200	40 " +	20 " ?	6	12	11200	"		14½°	B
		473	bot. 10'	880	25 " +	25 " +	10	10	11200				
1:40 "		474 (2nd)	1'	2800	40 " +	40 " +	12	12	9600	"		14½°	C
		475	bot. 47' 20'	2000	40 " +	30 " +	12	11	11000				
2:00 "		476	45'	1060	30 " +	30 " +	12	10	14200				
		477 (2nd)	1'	4240	40 " +	25 " +	15	12	10500	"		14°	D
		478	bot. 20'	2540	25 " +	40 " +	35	10	11400				
2:15 "		479 (2nd)	1'	4800	40 " +	60 " +	18	12	11600	"		13¾°	E
		480	20'	2750	40 " +	60 " +	20	12	11800				
		481	bot. 35'	2000	40 " +	25 " +	20	13	12500				
2:35 "		482 (1st)	1'	5200	60 " +	70 " +	18	11	11200	Slack		14°	F
		483	bot. 12' 10'	4800	40 " +	40 " +	25	15	11400				
2:45 "		484 (2nd)	1'	1200	25 " +	25 " +	22	15	10100	Flood		14½°	A
		485	bot. 10'	900	30 " +	0 neut 0	20	12	11800				
3:05 "		486 (2nd)	1'	1040	25 " +	15 acid ?	23	15	10200	"		14½°	B
		487	bot. 10'	720	25 " +	0 neut 0	8	14	10600				
4:10 "		488 (2nd)	1'	1600	50 " +	25 acid +	18	15	8500	"		14½°	C
		489	20'	1020	50 " +	20 " ?	3	14	11000				
		490	bot. 45'	540	40 " +	0 neut 0	3	10	12500				
		491 (2nd)	1'	1200	60 " +	25 acid +	3	15	9300	"		14°	D
		492	bot. 20'	840	60 " +	15 " ?	5	12	11300				

R.E.W.

(13)

Date & Hour.	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Presumptive B. Coli 1 C.C.	Presumptive B. Coli 10 C.C.	Turbidity	Color	Chlorine Pts per mil.	Tide	Wind	Temp. of Water	Location & Remarks
Jan Cont.		493 (204)	1	3080	70% acid +	40% acid +	3	15	10800	Flood	S.E. mod.	13½°	E Bay Ridge Channel
		494	20	1600	70 " "	25 " "	2	11	12000				
		495	bot. 35	920	50 " "	15 " "	7	10	11800				
		496	1	3600	70 " "	25 " "	7	11	11400	Flood		14°	F. 100' from B'klyn shore
Jan 19/07		497	bot. 10	2400	40 " "	25 " "	5	13	8400				
9:40 a.m.	30	498 (230)	1	6050	60 " "	40 " "	3	10	11700	1st hr. after M Flood	S.W. mild	14½° C	E River
		499	bot. 43 20	5300	25 " "	30 " "	3	10	12100			16°	100' off Pier 10 N.Y.
		500	40	4240	40 " "	25 " "	4	10	11400			16°	
11 "		501 (231)	1	7400	50 " "	40 " "	4	10	10800	Flood		16½°	500' " " " "
		502	bot. 52 20	3180	50 " "	25 " "	4	10	10800			16°	
		503	50	2860	30 " "	20 " "	3	10	11700			16°	
11:20 "		504 (232)	bot. 38 1	3500	40 " "	25 " "	3	10	9300	"		16½°	Midstream
		505	20	2320	25 " "	25 " "	3	10	11600			16°	
		506	36	2220	40 " "	0 neut 0	3	10	13100			16°	
12 M		507 (233)	1	4770	60 " "	30 acid +	4	11	9300	"		16½°	500' off Pier "10 B'klyn
		508	20	3380	60 " "	25 " "	4	11	11500			16°	
		509	bot. 45	2320	25 " "	0 neut 0	4	10	12900			16°	
12:30 P.M.		510 (234)	1	9480	70 " "	40 acid +	3	11	8100	"		16½°	100' " " " " "
		511	bot. 47 20	7400	40 " "	40 " "	3	12	10800			16°	
		512	45	4350	40 " "	25 " "	4	10	11500			16°	
1:45 "		513 (235)	1	4770	60 " "	50 " "	3	10	10300	Est. Mn. Flood "		16½°	100' " " " " N.Y.
		514	bot. 42 20	4240	40 " "	40 " "	3	10	13100			16°	
		515	40	2430	40 " "	30 " "	4	10	11900			16°	
3:15 "		516 (236)	1	4240	50 " "	40 " "	3	10	9300	Flood		16½°	500' " " " "
		517	20	3180	40 " "	25 " "	4	10	10900			16°	
		518	bot. 50	2120	25 " "	0 neut 0	7	10	13900			16°	
2:15 "		519 (237)	1	5830	40 " "	25 acid +	4	10	9500	"		16½°	Midstream
		520	bot. 36 20	3180	40 " "	0 neut 0	broken in transit.					16°	
		521	35	1590	30 " "	0 " 0	8	10	13100			16°	
3:30 "		522 (238)	1	3600	50 " "	25 acid +	3	10	10200	"		16½°	500' off Pier "10 B'klyn
		523	20	2120	30 " "	25 " "	3	10	11000			16°	
		524	bot. 48	1980	25 " "	0 neut 0	3	10	12600			16°	
3:45 "		525 (240)	1	6360	70 " "	40 acid +	3	10	11300	Last of Flood nearly Slack		16½°	100' " " " "
		526	bot. 46 20	4240	60 " "	30 " "	3	10	11300			16°	
Jan 27		527	45	3180	25 " "	20 " "	3	10	12800			16°	
9:30 "	10	528 (241)	1	1120	40 " "	25 " "	18	20	5700	Ebb	N.W.	14°	Spuyten Duyvil Cr. Draw
		529	15	1000	25 " "	0 neut 0	20	20	5700	Slowest Ebb			
2:20 "		530 (242)	bot. 16 1	2120	40 " "	25 acid +	15	20	6200			19°	N.R. midstream 1000 below Kingsbridge Hudson
		531	15	1900	40 " "	15 " "	18	20	5700	Ebb			
2:40 "		532 (243)	1	4240	50 " "	25 " "	18	22	6200			19°	" " Kingsbridge.
		533	" 15	3180	40 " "	0 neut 0	18	22	6600	Ebb			

(14)

Date & Hour.	No. Samples taken	Serial Numbers.	Depth of Sample.	Bacteria per c.c.	Dextrose Broth. 24 Hrs. Presumptive 1 c.c.	Dextrose Broth. 24 Hrs. B. Coli 1 c.c.	Turbidity	Color.	Chlorine Pts per mil	Tide	Wind	Temp. of Water	Location & Remarks.
Jan 27 Cont 1:30 P.M.		534 (249)	bot 20'	2860	50% acid +	40 acid +	8	18	8700	Slack	N.W.	19°6	Harlem River midstream off Dyckman St.
4 "		535	15	2120	25 " +	30 " +	8	15	11000				
		536 (250)	1	6360	70 " +	40 " +	8	18	16300	"	"	19°	
		537	15	4240	50 " +	40 " +	9	12	12300				" midstream Highbridge.
July 30 '07 9:30 a.m.	55	538	1	7500			2	14	11900	Slack	3-4 miles	24½°	
		539	20	4000			2	14	13100			22°	Hudson River
		540	bot. 40	4000			18	12	13500			20½°	100' off Pier "A"
9:50 "		541	1	6900			3	14	12100				
		542	20	5700			2	12	13100				500' " "
		543	40	4300			2	12	13900				
		544	bot. 46	3200			2	12	14300				
10 02 "		545	1	6400			3	14	12500				¼ way across
		546	20	5200			3	14	12500				
		547	40	3800			2	13	13300				
		548	bot. 50	2300			2	14	14000				
10:30 "		549	1	5400			2	15	12500				½ " "
		550	20	3500			2	14	13200				
		551	bot. 40	2800			3	14	14000				
10:45 "		552	1	5900			3	14	12800				¾ " "
		553	20	3700			4	15	13600				
		554	bot. 30	2900			4	14	14300				
11:15 "		555	1	6200			3	14	12500				500' off Jersey
		556	20	5100			3	15	13000				
		557	bot. 30	3500			4	14	13700				
11:03 "		558	1	6600			2	16	12300				100' " "
1:45 P.M.		559	bot. 20	5200			6	15	12300				
		560	1	5900			8	11	14400	Flood	3-3 miles	21½°	Hudson River
		561	20	5200			2	12	14600			21°	100' off Pier "A" N.R.
		562	bot. 40	3500			2	10	12700			20°	
1:35 "		563	1	5300			2	11	15000				300' " " " "
		564	20	4400			3	10	15000				
		565	40	3300			2	10	15100				
		566	bot. 46	2500			3	9	13500				
1:50 "		567	1	5100			3	12	14500				¼ way across
		568	20	5200			4	12	15500				
		569	40	3500			2	8	14600				
		570	bot. 50	2700			2	10	16000				
2:05 "		571	1	4000			2	14	12200				½ " "
		572	20	3300			2	12	13100				
		573	bot. 40	2900			3	8	16700				

(15)

Date & Hour	No. Samples taken	Serial Numbers.	Depth of Sample	Bacteria per C.C.	Lactose Bile 48 hrs. Presumptive C.C.	Lactose Bile 48 hrs. B. Coli C.C.	Turbidity	Color	Chlorine M.G. per ml.	Tide	Wind	Temp. of Water.	Location & Remarks.
2:20 P.M.		574	1'	4100			3	12	14200				
		575	20'	3900			3	12	14800	Flood	5.3 miles		¼ way across.
		576	bot. 39'	2300			2	12	15100				
2:30 "		577	1'	5900			3	12	14200				
		578	20'	5500			3	12	15300				500' from Jersey
		579	bot. 30'	2500			2	12	15000				100' " "
2:42 "		580	1'	4700			3	13	15000				
		581	bot. 20'	4400			3	11	15200				
2:45 "		582	1'	6600			4	12	14000	Ebb.	5. mile	24°	Hudson River
		583	20'	6200			3	9	14800				100' from Pier "a"
		584	bot. 40'	3400			3	8	16200			20½°	500' " " "
2:52 "		585	1	5600			3	12	15000				
		586	20	5100			4	12	15000				
		587	40	3700			3	11	15700				
		588	bot. 46	2700			3	9	15600				¼ way across
4:05 "		589	1	4200			4	12	14400				
		590	20	4700			2	11	14900				
		591	40	3500			2	12	14900				
		592	bot. 50	2300			3	14	14900				
4:18 "		593	1	3900			3	12	14300				⅓ " "
		594	20	3100			2	12	14100				
		595	bot. 40	2100			3	10	15300				⅔ " "
4:30 "		596	1	3300			2	12	14500				
		597	20	3000			3	12	14300				
		598	bot. 30	2800			3	13	15200				500' from Jersey
4:50 "		599	1	4400			3	13	14600				
		600	20	4000			3	12	14400				
		601	bot. 30	3100			4	14	14900				100' " "
4:55 "		602	1	3600			4	14	14200				
		603	bot. 20	5900			4	13	14700				
Aug 5 8:10 A.M.	21	604 (1st)	1	4400	40% acid +	25 acid +	2	10	13600	Ebb.	5 W. mile	22°	E. River & bet. Gov Isl'd & Battery mid. Butler Milk Ch. ap 38 st Bldg
8:20		605 (2nd)	1	5900	40 " "	30 " "	2	9	13600				
		606	bot. 40	2300	30 " "	25 " "	2	8	13400				Foot Conover St. 100' out.
8:30 "		607 (3rd)	bot 22' 1	8100	50 " "	40 " "	3	13	12900				
		608	20	5100	30 " "	40 " "	3	8	13600				E 31st Anchorage W buoy off Conover St
8:41 "		609 (4th)	1	4000	40 " "	25 " "	4	9	13400				
		610	bot. 25	2800	25 " "	10 " "	3	10	13000				Gowanus Bay Center
8:58 A.M.		611 (5th)	1	1300	70 " "	40 " "	3	9	13800				
9:00 "		612 (6th)	1	1600	80 " "	40 " "	2	13	13200				- Canal below Ham St. Br.
9:15 "		613 (7th)	1	3400	40 " "	30 " "	3	11	13300				Anchorage of Gowanus Bay 1 mile out.
		614	bot. 12	4400	30 " "	25 " "	3	13	13500				
9:25 "		615 (8th)	1	8800	50 " "	40 " "	2	11	14200				200' off 53 St. Bldg.
		616	bot. 35	4500	35 " "	25 " "	2	14	13800				

(16)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per c.c.	Coliform Bids 48 hrs Presumptive I.C.C.	Coliform Bids 48 hrs B Coli I.C.C.	Turbidity	Color	Chlorine Mil per mil	Tide	Wind	Temp. of water	Location & Remarks
Aug 8 Sat 10:15 a.m.	1	617 (10c)	1	8300	100 acid +	25 acid +	3	30	18500			82°	200' off 31st St Bridge
		618	Surf 40	5200	60 " +	25 " +	7	15	18100				
1:40		619 (10c)	Surf 25' 1	4600	35 " +	30 " +	6	35	13500				Anchored off 73rd St
		620	20	4100	30 " +	25 " +	8	9	13700				
2:15		621 (10c)	1	1200	25 " +	0 Presumptive	8	8	12700	NW Flood			Buttons 400 Ft. Lafayette
		622	Surf 45' 40	800	20 " +	" " +	8	9	14600				
3:20		623 (10c)	1	900	20 " +	" " +	3	11	10700				Entrance to Lower Bay center
		624 (10c)	Surface 100	300	0 Presumptive	" " +	6	7	14400				End of Buttons.
4:45 P.M. 50 c.m.	45'	625	1	8700	60 acid +	40 acid +	3	14	13600	Ebb	S.W. mile	82½°	East River
		626	20	7000	30 " +	40 " +	4	8	18200				100' off Pier 10 Man.
		627	Surf 40	9500	30 " +	25 " +	4	9	13700			81°	
6 "		628	1	6400	45 " +	25 " +	2	5	13300				300' off " " "
		629	Surf 45' 20	5400	50 " +	30 " +	4	9	13900				
		630	40	3600	40 " +	25 " +	4	9	13300				
6:40		631	1	9200	30 " +	25 " +	3	10	12900				Midstream
		632	20	3200	30 " +	25 " +	3	10	13200				
		633	Surf 40	2000	25 " +	0 Presumptive	3	12	13200				300' off Pier 10 Bridge
8:20 "		634	1	6700	60 " +	30 acid +	5	16	13700				
		635	Surf 45' 20	6100	30 " +	40 " +	6	22	13500				
		636	40	3300	40 " +	25 " +	3	9	13900				100' " " " "
9 "		637	1	7400	30 " +	25 " +	5	8	14400				
		638	Surf 45' 20	3800	30 " +	30 " +	2	9	13800				
		639	40	4200	25 " +	30 " +	3	9	13300				100' " " " Man.
12:30 P.M.		640	1	6400	60 " +		5	10	13300	Slack	W. ½ mile		
		641	20	4500	40 " +		3	9	13800				
		642	Surf 40	3800	40 " +		3	12	13100				300' " " "
1:40 "		643	1	5300	25 " +		3	11	13700				
		644	Surf 45 20	4400	30 " +		3	10	12600				
		645	40	2100	25 " +		3	9	14000				Midstream
3:15 "		646	1	4900	30 " +		3	10	14000				
		647	20	4000	30 " +		3	14	14200				
		648	Surf 40	2400	45 " +		3	14	13800				300' off Pier 10 Bridge
5:0 "		649	1	6300	30 " +		3	12	13400				
		650	Surf 45' 20	2700	30 " +		3	11	13600				
		651	40	1900	25 " +		4	20	13800				100' " " " "
7:00		652	1	5200	60 " +		4	8	14200				
		653	20	3800	50 " +		4	10	12400				
		654	Surf 45' 40	3600	50 " +		3	9	13500				100' " " " Man.
8:55 "		655	1	5300			2	10	13800	Flood	W. ½ mile	82½°	
		656	20	4200			3	9	13500				
		657	Surf 40	3000			4	10	11800				

Cross section East River Ebb & Flood.

(71)

Date & Hour	No. Samples Taken	Serial Numbers	Depth of Sample	Bacteria per c.c.	Lactose Bile 48 hr. Presumptive 1 c.c.	Lactose Bile 48 hr. B. Coli 1 c.c.	Turbidity	Color	Chlorine Pts per m	Tide	Wind	Temp. of Water	Location & Remarks.
Aug 6 Gen'l 5:04 PM		638	/	5000			2	11	19500	Flood	W Hy mild	22½°	East River 300' off Pier 10, Man.
		639	Bot 45' 20	3400			1	8	12900				
		640	40	2900			2	10	13100				Midstream
10 "		641	/	3600			2	14	1300				
		642	20	3200			2	9	15100				
		643	Bot 40	2000			2	9	13700				300' off Pier 10 Brklyn.
111 "		644	/	8300			2	12	12700				
		645	Bot 40	5900			2	11	13400				
		646	40	4400			2	12	12500				100' " " " "
121 "		647	/	8850			3	17	12800				
		648	45' 20	7100			2	10	13000				
		649	40	4600			2	7	11400				
3:03 P.M.		650	/	25500	40% acid +	30% acid +	4	65	13900	Ebb	S.E. mild	23°	Hallowell Bay - foot of Division Ave.
6:30 A.M.	18	670	Bot 15'	18000	50 " +	30 " +	3	18	12800	"			" foot Cross St.
		671	/	21000	70 " +	30 " +	8	35	14200				
7:17 AM		672	Bot 15'	16000	40 " +	25 " +	3	22	14100	"			" at Market Yard of Bayl.
		673	/	12500	60 " +	35 " +	2	11	13800				
		674	Bot 15'	9900	30 " +	30 " +	3	16	13700	"			Atlas Basin foot Carroll St.
9:10 P.M.		675	/	10500	60 " +	25 " +	7	180	14500				
11 "		676	20	7400	30 " +	10 " 0	2	15	15100				
		677	Bot 30	6900	25 " +	15 " 0	1	13	14100	Flood			" " " William St.
		678	/	3900	25 " +	40 " +	1	14	14600				
1:45 "		679	20	5300	40 " +	30 " +	2	10	14100				
		680	Bot 30	6100	25 " +	20 " 7	3	12	14900	"			" " " Commerce St.
2:41 "		681	/	8900	60 " +	25 " +	8	13	14100				
		682	Bot 46' 20	4800	40 " +	25 " +	5	15	14500	"			Erie Basin S.W. Cor.
3:47 "		683	/	4300	25 " +	30 " +	2	15	14300				
		684	Bot 23' 20	3280	30 " +	15 " 0	9	18	13800	"			" " " N.E. "
4:42 "		685	/	9200	35 " +	40 " +	4	10	14500				
		686	Bot 23 20	6000	35 " +	25 " +	2	12	10500	Slack		23°	Coney Is. Creek (mouth)
Sept 6		687	/	10500	40 " +	40 " +	2	25	14400				Gravesend Bay & Bet. Yacht Clubs
12 P.M.	13	688											creek
		689	Bot 8	7300	40 " +	30 " +	1	12	15500				
1:33 "		690	/	3700	25 " +	15 " 0	1	10	15200	"			" " 200' off All. Yacht Club.
		691	Bot 4	1100	25 " +	10 " 0	1	8	15300				
1:38 "		692	/	2200	30 " +	20 " 9	1	8	15300	"			
		693	Bot 6	1500	10 " 0	0 next 0	1	9	13800	Flood		23°	Gowanus Bay Center
2:26 "		694	/	9300	60 " +	25 cold +	2	12	14500				
		695	20	4500	40 " +	30 acid +	1	9	14800				
		696	Bot 30	3400	25 " +	25 " +	1	7	13200	"			" Canal 300' below Ham. Ave. Bridge
3:9 "		697	/	17000	70 " +	40 " +	2	32	14300				
		698	Bot 24 20	9400	50 " +	25 " +	2	16					

(18)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Lactose Bile 48 hrs Presumptive C.C.	Lactose Bile 48 hrs B Coli C.C.	Turbidity	Color	Chlorine p.p.m. per mil	Tide	Wind	Temp. of Water	Location Remarks
Sept 6 Cont'd		699	bot. 24 1	15000	60 acid +	30 acid +	3	18	14300	Flood			Gowanus Bay Ft 20 St.
		700	20	8200	35 " +	10 " 0	5	30	13900				Kill Van Kull
3:20 P.M.	28	701	1	9100	60 " +	40% acid +	1	12	14300	Ebb	S.	23°	50' off W. Brighton S.I.
Sept 7 11:30 a.m.		702	10	7600	40 " +	30 " +	1	12	14000				
		703	bot. 15	5700	40 " +	25 " +	2	11	13900				1/4 way across
11:40 "		704	1	8300	50 " +	35 " +	1	9	14000				
		705	bot. 24 10	5600	50 " +	30 " +	1	13	14000				
		706	20	5300	40 " +	25 " +	2	9	14000				1/2 " "
11:50 "		707	1	7400	60 " +	40 " +	2	11	14000				
		708	bot. 24 10	4200	40 " +	35 " +	2	9	14000				
		709	20	3600	25 " +	20 " +	2	14	14300				
12 M.		710	1	5400	50 " +	50 " +	1	10	14300				3/4 " "
		711	bot. 21 10	5100	40 " +	40 " +	1	8	14300				
		712	20	3200	40 " +	30 " +	1	9	14300			22½°	50' from Constable St.
12:15 P.M.		713	1	4900	35 " +	35 " +	2	12	14600				Chimney Oxford Copper Co.
		714	bot. .5	4300	50 " +	25 " +	2	15	14200				50' off W. Brighton S.I.
1:30 "		715	1	7000	60 " +	50 " +	2	20	14200	Flood	S		
		716	10	5600	50 " +	20 " +	2	25	13800				
		717	bot. 15	4400	25 " +	30 " +	3	17	14200				1/4 way across
1:40 "		718	1	7800	45 " +	30 " +	2	11	13700				
		719	bot. 24 10	6600	40 " +	25 " 0	1	14	13800				
		720	20	4100	40 " +	10 " 0	2	10	13500				1/2 " "
1:53 "		721	1	5400	35 " +	45 " +	2	13	13000				
		722	bot. 24 10	3800	30 " +	25 " +	4	12	13000				
		723	20	2700	30 " +	0 nent. 0	3	10	13400				3/4 " "
2:05 "		724	1	4200	50 " +	35 acid +	4	13	13400				
		725	bot. 21 10	3200	35 " +	25 " +	1	10	14000				
		726	20	2700	25 " +	10 " 0	1	11	14000				50' from Constable Pt.
2:20 "		727	1	4300	55 " +	35 " +	2	13	13500				
		728	bot. 5	3800	40 " +	0 nent. 0	1	12	13500			23½°	Harlem Riv. at 3 Av. Bridge
Sept 8 9:30 a.m.	16	729	1	8200	60 " +	40 acid +	1	14	11700	Flood → Hudson			50' from S. Shore
		730	bot. 14 10	5700	40 " +	30 " +	1	11	12100				Midstream
9:40 "		731	1	7100	50 " +	40 " +	2	10	12100				
		732	bot. 24' 10	5300	35 " +	25 " +	1	10	13200				
		733	20	4400	40 " +	25 " +	1	12	13400				50' from N. Shore
9:55 "		734	1	7400	50 " +	35 " +	2	20	11700				
		735	bot. 25 10	7800	40 " +	30 " +	1	11	12500				
		736	20	4700	35 " +	25 " +	1	12	12500				50' " S "
2 P.M.		737	bot. 11 1	6900	40 " +	25 " +	1	9	14000	Ebb → E. River			
		738	10	4900	40 " +	20 " +	1	8	14600				

Cross Section Harlem Flood 1st

Cross Section Kill Van Kull Ebb & Flood

(19)

Date & Hour.	No. Samples taken	Serial Numbers	Depth of Samples	Bacteria per c.c.	Lactose Bile 48h Presumptive I.C.C.	Lactose Bile 48h B. Coli I.C.C.	Turbidity	Color	Chlorine p.p.m. per mil	Tide	Wind	Temp. of Water.	Location & Remarks.
Sept 6 Cont		739	1	6100	50% acid +	30 acid +	1	9	14600	Ebb.			Harlem River cont
12.10 P.M.		740	bot. 2	4800	26 " +	25 " +	2	12	14300	→E. River			Midstream
		741	10	3700	35 " +	16 " 0	2	12	14300				
		742	1	5700	45 " +	25 " +	18	-	13400				50' from N. Shore
2.25 P.M.		743	bot 22'	4900	60 " +	30 " +	1	14	14100				
		744	10	3900	35 " +	0 neut 0	2	23	14600			22°	Narrows
Sept 10	18	745	1	2200	26 " +	25 acid +	2	7	15100	Flood			E. Shore 300' from Ft. Hamilton
11 A.M.		746	bot 10	1800	30 " +	25 " +	1	7	15900				
		747	1	1600	40 " +	30 " +	1	6	15400				Midstream
8.20 "		748	20	1600	25 " +	0 neut 0	2	6	15600				
		749	40	380	15 " 0	0 " 0	2	7	15900				
		750	bot 85	180	0 net 0	0 " 0	2	7	15900				
		751	1	2500	40 acid +	35 acid +	1	7	14200				
11.45 "		752	30	1900	30 " +	25 " +	1	5	15900				W. Shore 100' from Ft. Wadsworth
		753	bot 60	580	0 net 0	0 neut 0	1	7	15700				300' off Ft. Hamilton
		754	1	4300	50 acid 0	30 acid +	3	10	14700	Ebb.			
2.30 P.M.		755	bot. 10	3500	50 " +	25 " +	6	10	15700				
		756	1	3900	40 " +	25 " +	3	8	14800				Midstream
		757	20	3000	35 " +	40 " 1	3	10	14600				
		758	40	840	25 " +	0 neut 0	4	11	14900				
2.45 "		759	bot. 85	290	0 net 0	0 " 0	2	9	14600				
		760	1	5100	50 acid +	35 acid +	2	11	14900				100' off Ft Wadsworth
3 "		761	30	3700	40 " +	25 " +	3	8	14600				
		762	bot. 60	1100	25 " +	0 neut +	2	8	14900				
Sept. 11	18	763	1	6200	40 " +	25 acid +	25	240	12700	1st Ebb.		22 1/2°	Newtown Cr.
1. P.M.		764	bot. 15	4000	30 " +	30 " +	4	65	12700				Johnson & Morgan Ave
		765		5900	30 " +	25 " +	15	250	11700	"			Met. Ave Bridge
1.25 "		766	bot 15	4800	45 " +	20 " +	15	170	12400	"			Maspeth Ave. "
		767	1	4900	60 " +	30 " +	2	30	12400	"			
1.45 "		768	bot. 20	3900	46 " +	30 " +	44	170	12600	"			Meeker Ave. "
		769	1	4300	35 " +	25 " +	15	23	12900	"			
2 "		770	bot. 19	3200	30 " +	10 " 0	50	25	12700	"			Greenpoint Ave "
		771	1	6000	40 " +	30 " +	3	18	13200	"			
2.20 "		772	bot. 17	4000	25 " +	0 neut 0	3	22	13200	"			
2.45 "		773	1	5900	50 " +	30 acid +	3	18	13500	"			Vernon Ave. "
		774	bot. 18	3600	50 " +	25 " +	2	22	13500	"			below " " "
3 P.M.		775	1	2400	25 " +	0 neut 0	700	1300	12700	"			
Sept 12	18	776	1	5500	50 " +	35 acid +	2	22	11300	Flood	N.W. mod.	22°	Harlem River.
11.20 A.M.		777	bot 5	4700	40 " +	25 " +	2	14	11100	→Hudson			Pier N.Y. in Randalls Island
		778	1	8300	50 " +	30 " +	2	18	9000				Midstream midway
11.40 "		779	bot 22 10	7400	25 " +	30 " +	2	13	8800				bet 2 & 3 Ave. Bridges.
		780	20	4300	35 " +	25 " +	2	19	9000				

Cross section Narrows Flood Ebb

Newtown Creek

(21)

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Presumptive I.C.C.	B. Coli I.C.C.	Turbidity	Color	Chlorine Pt per ml	Tide	Wind	Temp. of Water.	Location & Remarks.
													Harlem Riva (Cont.)
Sept 12 Cont.		781	1'	9200	40% acid +	40% acid +	1	13	7200	Flood	N.W. mod.	22°	Midstream ½ bet. 4th St & Mad. Ave. bridge
12 M.		782	bot 22'	6200	50 " +	25 " +	4	18	7200				
		783	20	5600	25 " +	30 " +	2	14	7500				
		784	1	6600	60 " +	40 " +	2	17	6500				" ½ bet. 145th St & N.Y.C. Bridge
1:10 P.M.		785	bot 21'	5900	50 " +	40 " +	3	17	6500				
		786	20	4200	30 " +	0 neut. 0	2	17	6300				W. Shore ½ bet. Putnam R.R. & High Bridge
1:25 "		787	bot 14'	3400	45 " +	25 acid +	5	17	6390				
		788	10	3700	30 " +	20 " +	3	17	6300				
1:40 "		789	bot 17	4400	25 " +	25 " +	3	22	6700				Midstream Dyckman St
		790	10	2700	25 " +	0 neut. 0	3	18	6700				
		791	1	3800	25 " +	35 acid +	3	22	7500				N. Shore of Kingsbridge
2:10 "		792	10	2900	30 " +	15 " 0	3	19	7500				
Sept. 16	4	793	bot 19	2100	15 neut. 0	0 neut. 0	2	17	7500	Ebb			
11:30 a.m.		794	1	8500	90 acid +	50 acid +	5	17	9000	N.W. 2:45 P.M.		22°	N. River Ft Gansevoort
		795	bot 9	6400	70 " +	30 " +	5	17	9000	Ebb.			inner end.
3 to P.M.		796	1	9500	80 " +	60 " +	4	15	9500	Flood			Gansevoort St.
		797	bot 12	7400	80 " +	45 " +	6	25	12000	Flood			
Sept. 17	4	798	1	19000	80 " +	50 " +	10	15	9000	Ebb			E. River Ft Oliver St. inner end.
11 a.m.		799	bot 5	13000	60 " +	60 " +	15	15	9500	Ebb.			" " "
2:30 P.M.		800	1	17000	80 " +	60 " +	12	17	11000	Flood			
Sept 25		801	bot 8	3500	70 " +	35 " +	10	17	12500	Flood			
11 a.m.	28	802	1	1080	40 " +	15 " 0	2	9	11600	Flood	N.W. 50 m.hrs	22½°	Newark Bay
		803	10	1400	40 " +	25 " +	2	10	11900				bet. Shooter's Isd & Light
		804	bot 30	700	25 " -	0 neut. 0	3	15	9800				
		805	1	6300	50 " +	25 acid +	3	15	10100				Bell Buoy off centerville
11:30 "		806	bot 22'	5300	60 " +	30 " +	4	11	10500				
		807	20	4800	45 " +	25 " -	4	17	8500				
		808	1	15000	70 " +	40 " +	7	22	8500				By Buoy #4
1:45 "		809	10	11000	60 " +	40 " +	4	18	8500				
		810	bot 12	13000	60 " +	30 " +	8	25	3900				" " #11
		811	1	38000	80 " +	50 " +	9	20	4400				
12:20 P.M.		812	10	44000	70 " +	60 " -	9	20	4100				
		813	bot 15	36000	80 " +	45 " +	25	27	540				Mouth Passaic River
		814	1	57000	80 " +	70 " +	30	27	850				
12:45 "		815	bot 8	51000	80 " +	70 " +	25	27	640	Ebb	N.W. 40 m.hrs		" " "
		816	1	69000	80 " +	60 " +	125	23	790				
1:30 "		817	bot 8	59000	70 " +	70 " +	40	22	1480				
		818	1	52000	80 " +	70 " +	40	24	2820				Newark Bay by bell buoy #11
1:10 "		819	10	38000	80 " +	60 " +	40	24	4600				
		820	bot 15	25000	70 " -	50 " +	8	26	5800				
							1	20	8				Croton Water

Newark Bay Series run.

(21)

Date & Hour	No. Samples taken	Serial Number	Depth of Sample	Bacteria per C.C.	Presumptive 1 C.C.	B. Coli 1 C.C.	Turbidity	Color	Chlorine Parts per mil	Tide	Wind	Temp of water	Location & Remarks
Sept 25 Cont.		821	1'	26000	60 Acid +	60 Acid +	12	29	5900	Ebb.	N.W. Gentle	23½	Newark Bay by Buoy "A
2.15 P.M.		822	10'	24000	45 " +	65 " +	22	30	6400				
		823	bot. 12'	23000	30 " +	45 " +	8	20	7500				" " Ball Buoy off Centerville
		824	1'	19000	40 " +	40 " +	12	22	7700				
2.40 P.M.		825	bot. 24' 10	21000	50 " +	25 " +	20	20	7900				
		826	20	13000	35 " +	25 " +	8	19	10200				" " bet Shooters Is'd & Light
		827	1	5300	30 " +	30 " +	9	19	10400				
3.00 P.M.		828	10	2660	30 " +	25 " +	9	16	18600				Hudson River
	28	829	bot. 20	4800	40 " +	40 " +	2	22	3000				
Sept 26		830	bot. 11' 1	640	40 " +	25 " +	18	22	3300	Flood	N.W. Gentle	20°	100' off Spuyten Duyvil
10.30 A.M.		831	10	760	40 " +	25 " +	7	22	3300				
		832	1	590	50 " +	30 " +	8	22	3300				
		833	10	450	40 " +	20 " +	12	20	3800				¼ way across
10.45 A.M.		834	20	510	45 " +	10 " 0	35	20	4300				
		835	bot. 40	740	30 " +	25 " +	15	22	3300				
		836	1	230	25 " +	0 Nevt. 0	20	22	3400				½ " "
11.05 A.M.		837	bot. 24' 10	150	0 Nevt. 0	0 " 0	30	25	3800				
		838	20	340	30 Acid +	15 Acid 0	15	22	3400				¾ " "
		839	1	220	40 " +	0 Nevt 0	25	20	3400				
11.20 A.M.		840	bot. 22' 10	260	25 " +	25 Acid +	50	22	3800				
		841	20	540	35 " +	30 " +	20	22	3400				
		842	bot. 13 1	280	30 " +	15 " 0	15	20	3400				
11.40 A.M.		843	10	320	30 " +	0 Nevt 0	8	20	4200	Ebb	N.W. Gentle		100' from Jersey
		844	bot. 12 1	800	60 " +	40 Acid +	8	20	4200				" " Spuyten Duyvil
1.30 P.M.		845	10	690	30 " +	35 " +	8	19	4000				
		846	1	310	40 " +	30 " +	9	19	4000				¼ way across
		847	10	330	40 " +	15 " 0	9	18	4400				
1.55 P.M.		848	20	690	45 " +	25 " +	9	23	4800				
		849	bot. 40	610	30 " +	30 " +	8	20	4800				
		850	1	290	40 " +	0 Nevt. 0	9	19	4700				
2.00 P.M.		851	10	400	25 " +	15 Acid 0	9	18	4200				½ way across
		852	bot. 20	470	30 " +	25 " +	9	20	3700				
		853	1	150	20 " +	0 Nevt. 0	9	22	4400				¾ " "
20 P.M.		854	bot. 21' 10	400	30 " +	35 Acid +	9	22	4400				
		855	20	640	40 " +	35 " +	35	22	4400				100' from Jersey
		856	bot. 13' 1	550	40 " +	25 " +	20	22	3700				
2.30 P.M.		857	10	320	25 " +	10 " 0	40	22	4400				
Oct 1	17	858	bot. 15' 1	625000	80 " +	70 " +	30	55	2800	Ebb.		25	Gowanus Canal at Degraw St.
10.00 A.M.		859	10	380000	80 " +	60 " +	20	30	6200				
		860	bot. 13' 1	254000	80 " +	60 " +	25	60	4100				Union St. B'klyn.
10.20 A.M.		861	10	170000	70 " +	50 " +	25	60	7800				

Period of rainy weather prior to Sept. 26

Across Section Hudson River at Spuyten Duyvil

X20. P.21.

(22)

Date & Hour	No Samples Noted	Serial Numbers	Depth of Sample	Bacteria per C.C.	Presumptive B. Coli C.C.	B Coli per C.C.	Turbidity	Color	Chlorine P/M permil	Tide	Wind	Temp of Water	Location & Remarks.
Oct. 1 Cont		862	bot 11' 1	293000	80 Acid +	80 Acid +	30	30	6700	Ebb			Gowanus Canal Carroll St. Bridge
10.40 AM		863	10	85000	80 " +	60 " +	18	45	10300				
		864	bot 13 1	127000	80 " +	40 " +	40	01L	9800	"			3rd St. Bridge
11.00 A.M.		865	10	64000	70 " +	35 " +	35	90	3800				
		866	bot 15' 1	95000	70 " +	30 " +	45	01L	10300	"		23° C	Hamilton Ave Bridge
11.30 A.M.		867	10	54000	70 " +	40 " +	8	180	10300				
		868	1	64000	60 " +	60 " +	22	25	8400	"		32°	Center Gowanus Bay
12.15 P.M.		869	bot 22' 1	52000	70 " +	40 " +	8	14	10300				
		870	20	42000		25 " +	10	14	10800				
		871	1	808000	80 " +	70 " +	10	80	3800	Flood			100' from Sewer Ft. 65th St.
1.20 P.M.		872	bot 15	516000	80 " +	70 " +	10	40	3800				
		873	bot 20' 1	687000	80 " +	70 " +	8	30	7400	"			End Pier Ft 52 St. "
3.50 P.M.	9	874	15	193000	80 " +	40 " +	5	25	7400				
Oct. 2.		875	bot. 12 1	21000	60 " +	30 " +	8	65	3500	Ebb.		23°	Newtown Creek
11.50 A.M.		876	10	10000	65 " +	25 " +	8	60	10800				Nor. Ave. Bridge
		877	1	60000	60 " +	35 " +	16	70	9100	"			Slegg & Morgan
12.15 P.M.		878	bot 6	42000	45 " +	40 " +	8	35	10600				
		879	1	106000	45 " +	25 " +	12	30	10600	"			Meserole & "
1.30 P.M.		880	bot 3	82000	50 " +	30 " +	35	60	10600				
		881	1	16000	70 " +	50 " +	25	65	10600	"			Johnson & Morgan
1.56 "		882	bot 6	14000	50 " +	60 " +	25	65	10600	"			middle of Slip
2.25 "	15	883	1	64000	80 " +	45 " +	50	50	9200	"			S. Side
Oct 3		884	1	92000	80 " +	30 " +	8	18	9100				Below Kinnan Ave Bridge
11.00 A.M.		885	10	3000	50 " +	0 Neut B	8	18	9100	Ebb		22°	Chelsea Suit mill
		886	bot 20	1800	45 " +	0 " B	8	18	9100				
		887	1	18000	60 " +	30 Acid +	7	24	9800				Branch at Paige St.
12.20 P.M.		888	bot. 10	11000	60 " +	30 " +	7	20	10700	"			
1.15 "		889	1	16000	80 " +	40 " +	9	35	8600				Head Whale Creek Canal
1.55 "		890	1	19000	40 " +	40 " +	12	60	10600				Slip " " near Greenpoint
		891	bot 12 1	5000	80 " +	0 Neut 0	40	960	10800	"		Petroleum	Greenpoint Ave Bridge
1.05 "		892	10	9400	60 " +	0 " 0	9	50	11300			discharge	W.S. of Columbus Distilling Co.
	Newtown Creek	893	bot. 10 1	15000	40 " +	35 Acid +	95	30	9100			Laundry waste	Greenpoint Ave Br. N. Side of creek
2.15 "		894	10	22000	55 " +	25 " +	28	55	10300	"			
		895	1	14000	65 " +	30 " +	28	40	10100				Foot of Norman Ave
2.40 "		896	bot 6	21000	30 " +	25 " +	27	70	10300				
		897	1	16000	45 " +	40 " +	27	70	9800				Meeker Ave Br. S. Shore
3.25 "		898	bot 10	6600	40 " +	15 " 0	33	40	9800	"			
Oct. 19. 11.50 A.M.	9	899	1	8000	90 " +	25 " +	29	45	10600			22°	Foot Morgath Ave.
12.20 P.M.		900	1	12000	40 " +	35 " +	32	45	10300	Ebb			Cooper Glue Mfg. W. Shore
		901	1	13000	40 " +	40 " +	21	45	10500				De Hutts Glass Mfg.
1.30 "		902	bot. 7	21000	40 " +	35 " +	19	90	10300				

Date & Hour	No. Samples taken	Serial Numbers	Depth of Sample	Bacteria per C.C.	Presumptive 1 C.C.	B. Coli 1 C.C.	Turbidity	Color	Chlorine ppm per m/	Tide	Wind	Temp of Water	Location & Remarks.
10:30 A.M. to 2:40 P.M.		903	1'	16000	70 Acid 1	25 Acid 1	2000	40	10800	E.Bb.			Anchored (not fixed) Boat 800' E of Master of Ba. Ft Washington Ave.
2:40 "		904	1'	6000	65 " "	18 " "	2000	94	5700				120' E. " "
		905	1'	10000	65 " "	25 " "	25	40	10200				
		906	Bot. 8'	10000	60 " "	30 " "	20	35	10400				Ft Delaware Ave.
		907	1'	42000	70 " "	40 " "	65	50	5200				East River
3:05 " 4:10 "	24	908	1'	12700		50 " "	4	12	10200	E.Bb.	S.w. Mod.	19°	300' off L.I.R.R. Sta.
9:00 A.M.		909	Bot 10'	11700		90 " "	4	12	10400				L.I. City
		910	20'	9500		25 " "	2	9	10200				
		911	1'	10600		25 " "	3	10	10600	"			
10:00 A.M.		912	10'	8500		30 " "	4	8	10600				Dredge working near shore taking up Clay about 50 feet over tunnel
		913	20'	9800		30 " "	4	9	10800				
		914	1'	13800		90 " "	3	9	11600	"			
		915	10'	9500		90 " "	4	9	11600				
11:00 A.M.		916	20'	12200		30 " "	4	12	11700				
		917	1'	15900		50 " "	4	10	12200	E.Bb.			
6:05 P.M.		918	10'	6900		35 " "	7	9	12200				
		919	20'	8500		90 " "	4	8	12200				
		920	1'	10600		30 " "	7	8	12400	Slack	S.w. Mod.		
1 P.M.		921	10'	9500		25 " "	3	8	12600				
		922	20'	7900		25 " "	4	9	12600				
		923	1'	19100		50 " "	3	14	11900	Flood	W. Strong		At beginning of flood for 1/2 hour Scum of oil etc. from R.R. out of Newtown Creek.
2:00 P.M.		924	10'	14300		50 " "	3	11	12100				
		925	20'	8500		35 " "	4	10	12500				
		926	1'	17000		90 " "	3	7	12300	"			
3:00 P.M.		927	10'	14300		90 " "	4	7	12400				
		928	20'	9500		25 " "	4	10	12400				
		929	1'	15900		30 " "	4	9	12000	"			
4:00 P.M.		930	10'	13800		90 " "	4	10	12000				
		931	20'	11700		25 " "	4	9	12400				

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 21.

JAMES D. MAHER,
Commissioner.

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 257

METROPOLITAN SEWERAGE COMMISSION

INDEX

OF

STATIONS 1 TO 490

showing Chart Location and Samples Taken at each Station during 1907

Complainants Exhibit No 21.
James D. Maher
Commissioner

Station No.	Chart		Water Samples Nos.	Mud Samples Nos.
1	Battery	7	1	
2	Section	7	2	
3		4	3	
4	Narrows	4	4	
5	Section	4	5, 6	
6		4	7	
7	Gowanus	6	8	
8	Section	6	9	
9		4	10	
10		4	11	
11		4	12, 13	
12		4	14	
13		4	15, 16, 17, 18, 19, 20, 21, 22, 23	
14		4	24 to 47 incl.	
15	Narrows Section	4	48 to 51 incl. 873, 874	698
16		4	52, 53	
17		4	54, 55	
18		4	56, 57	12 to 16 incl.
19		4	58, 59	
20		4	72	1
21		4		2
22		4		3
23		4		4
24	Gowanus	6		5
25	Section	6		6
26	Battery Section	7		7
27		4	60, 61	
28		4	62, 63	
29	Narrows Section	4	64, 65	
30		4	66, 67	
31		4	68, 69	
32		4	70, 71, 73, 74	
33	Gowanus	6		8
34	Section	6		9
35	Narrows	4		10
36	Section	4		11
37	Battery Section	7	75-78; 97-100; 221-224, 534-540 incl. 560-562, 582-584	
38		7	79-82, 101 104; 225-228, 291-296, 302 307, 313-318, 324 329; 335-340 344-351, 357-362, 368-373; 379-389, 390 395; 401-406, 412-417; 423-428; 434-439, 541-544, 563-566; 585-589 incl.	

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 22.

X21-P.1.

(1).

39	Battery Section	7	88 96, 105 108, 229-232, 545-548, 567-570, 589-592, 87 89, 109 112, 223-226, 297-299 308-310, 319-321, 350 352, 361-363, 352-354, 363-365,	
40		7	374-376, 385-387, 396-398, 407-409, 418 420, 429-431, 440-442, 449-451, 569-571, 571-573, 593-595,	
41		7	90-92, 113-115, 237-239, 552 554 574-576, 596-598 93-94, 116-119, 240-242,	
42		7	320-321, 311-312, 322, 323, 333, 334, 344 345, 355, 356, 344, 367, 377 378, 388, 389, 399, 400, 410, 411, 421, 423, 432, 433, 443, 444, 555 557, 577-579, 599-601,	
43		7	95, 96, 119-122, 243-245, 558, 559, 580, 581, 602, 603	
44	Governors Section	6	131-137	17-21
45	Section	6	138-141	22-26
46	Lower Bay Coastal Section	2		27
47	Battery Section	7	142, 143	
48	Governors Section	6	144, 145	
49	Hill View No. 11 Section	5	146-148	
50		5	149-152	
51		5	153-154	
52		5	155, 156	
53		5	157, 158	
54		5	159, 164 161	
55		5	162-163	
56	Governors Section	4	164, 165	
57	Brooklyn Bridge	8	166, 167, 168	28
58	Blackwells Island	8	169, 170	29, 30, 31, 32, 33, 34
59		7	171, 172	35, 36, 37
60	Battery Section	7	173, 174	38, 39, 40, 41, 42, 43
61		7	175, 176	
62	Brooklyn	8	177, 178	
63	Bridge &	8	179, 180	
64	Blackwells Island	8	181, 182	
65	East River Section	9	183, 184	
66		9	185, 186	
67	Hardlocks Island Section	10	187, 188	
68	Blackwells Island Bridge	8		44-48
69	Battery Section	7	189, 190	49-53

X 21-P.2.

Station No.	Chart		Water Samples No.'s	Bed Samples No's
70	Battery Section	7	191-192	
71		7	193-194	
72		7	195-196	
73	Kill Van Kull Section	5	197 & 98	54-59
74		5	199-200	
75	Battery Section	7	201-202	60-65
76		7	203-204	66-71
77		7	205-206	72-77
78		7	207-208	78-83
79		7	209-210	84-89
80		7	211-212	90-95
81		7	213-214	96-101
82		7	215-216	102-107
83		7	217-218	108-113
84		7	219-220	114-119
85		7	246-247	120-125
86		7	248-249	126-130, 132-137
87		7	250-251	138-143
88		7	252-253	144-149
89		7	254-255	150-155
90		7	256-257	156-161
91		7	258-259	162-167
92		7	260-261	168-173
93		7	262-263	174-177
94	Kill Van Kull Section	5	264-266	178-183
95		5	267-(269)?	184-189
96		5	269-270	190-195
97		5	271-272	196-201
98		5	273-274	202-207
99		5	275-276	208-213
100		5	277-278	214-219
101		5	279-280	220-225
102		5	281-282	226-231
103		5	283-284	232-237
104		5	285-286	238-243
105	Gowanus Section	6	287-288	244-247
106	Narrows Section	4		248-249
107		4	289-290, 871, 872	250, 254, 697
108	Lower Bay Central Section	2		255-260
109		2		261
110		2		262
111	Narrows Section	4		263-268
112		4		269-274
113		4		275-280
114		4		281-286
115	Kill Van Kull Section	5		287-292

X 21 - P. 3

Brooklyn Bridge
Manhattan Bridge
Williamsburg Bridge
Queensboro Bridge
Hell Gate Bridge
Harlem River Lift Bridge
Madison Ave. Bridge
Park Ave. Bridge
Willis Ave. Bridge
Third Ave. Bridge
Alexander Ave. Bridge
Lincoln Tunnel
Holland Tunnel
Manhattan
Bronx
Brooklyn
Queens
Staten Island
Newark
Jersey City
Hoboken
Weehawken
Union City
West New York
Guttenberg
North Bergen
Secaucus
Kearny
Harrison
Bayonne
Elizabeth
Linden
Rahway
Perth Amboy
Sayreville
South Amboy
Old Bridge
Matawan
Aberdeen
Keyport
Union Beach
Atlantic Highlands
Sandy Hook
Port Monmouth
Middletown
Red Bank
Shrewsbury
Long Branch
Deal
Asbury Park
Ocean Grove
Belmar
Spring Lake
Sea Girt
Manasquan
Point Pleasant
Bay Head
Mantoloking
Brick Town
Lakewood
Toms River
Seaside Park
Seaside Heights
Island Heights
Lakehurst
Whiting
Manchester
Jackson
Lakehurst
Browns Mills
Pemberton
Vincentown
Medford
Mount Holly
Lumberton
Cinnaminson
Palmyra
Riverside
Delanco
Beverly
Edgewater Park
Burlington
Florence
Roebling
Bordentown
Trenton
Yardville
Hamilton Square
Princeton
Kingston
Rocky Hill
Griggstown
Somerville
Bound Brook
Dunellen
Middlesex
Plainfield
North Plainfield
Bridgewater
Raritan
Somerville
Flemington
Lambertville
New Hope
Stockton
Frenchtown
Milford
Riegelsville
Belvidere
Phillipsburg
Easton
Pen Argyl
Wind Gap
Bangor
Portland
Delaware Water Gap
Stroudsburg
East Stroudsburg
Mount Pocono
Tannersville
Cresco
Canadensis
Henryville
Stokes Forest
Hainesburg
Blairstown
Hope
Johnsonburg
Columbia
Delaware River
Hudson River
Raritan River
Passaic River
Newark Bay
Arthur Kill
Kill Van Kull
Upper New York Bay
Lower New York Bay
Sandy Hook Bay
Raritan Bay
Shrewsbury River
Navesink River
Shark River
Manasquan River
Barnegat Bay
Toms River
Metedeconk River
Mullica River
Great Egg Harbor River
Tuckahoe River
Maurice River
Cohansey River
Delaware Bay
Cape May
Cape May Point
West Cape May
Wildwood
Wildwood Crest
North Wildwood
Anglesea
Stone Harbor
Avalon
Sea Isle City
Ocean City
Somers Point
Egg Harbor City
Pleasantville
Atlantic City
Ventnor City
Margate City
Longport
Absecon
Brigantine
Oceanville
Leeds Point
Port Republic
Smithville
Pomona
Egg Harbor Township
Hammonton
Folsom
Buena
Vineland
Landis
Millville
Bridgeton
Port Norris
Shiloh
Fairton
Newport
Dividing Creek
Rosenhayn
Upper Deerfield
Bridgeton
Salem
Penns Grove
Carneys Point
Pennsville
Oldmans
Woodstown
Pilesgrove
Alloway
Quinton
Salem
Hancocks Bridge
Lower Alloways Creek
Mannington
Monroeville
Elmer
Daretown
Upper Pittsgrove
Mullica Hill
Swedesboro
Woolwich
Gibbstown
Paulsboro
Gloucester City
Brooklawn
Barrington
Haddonfield
Collingswood
Westmont
Haddon Heights
Lawnside
Magnolia
Audubon
Oaklyn
Merchantville
Pennsauken
Camden
Gloucester
Woodbury
Glassboro
Mantua
Pitman
Washington
Franklin
Deptford
Wenonah
Sewell
Mount Ephraim
Barrington
Haddon Township
Haddonfield
Collingswood
Westmont
Haddon Heights
Lawnside
Magnolia
Audubon
Oaklyn
Merchantville
Pennsauken
Camden
Gloucester
Woodbury
Glassboro
Mantua
Pitman
Washington
Franklin
Deptford
Wenonah
Sewell
Mount Ephraim
Atlantic Ocean
Delaware River
Delaware Bay
Cape May
Cape May Point
West Cape May
Wildwood
Wildwood Crest
North Wildwood
Anglesea
Stone Harbor
Avalon
Sea Isle City
Ocean City
Somers Point
Egg Harbor City
Pleasantville
Atlantic City
Ventnor City
Margate City
Longport
Absecon
Brigantine
Oceanville
Leeds Point
Port Republic
Smithville
Pomona
Egg Harbor Township
Hammonton
Folsom
Buena
Vineland
Landis
Millville
Bridgeton
Port Norris
Shiloh
Fairton
Newport
Dividing Creek
Rosenhayn
Upper Deerfield
Bridgeton
Salem
Penns Grove
Carneys Point
Pennsville
Oldmans
Woodstown
Pilesgrove
Alloway
Quinton
Salem
Hancocks Bridge
Lower Alloways Creek
Mannington
Monroeville
Elmer
Daretown
Upper Pittsgrove
Mullica Hill
Swedesboro
Woolwich
Gibbstown
Paulsboro
Gloucester City
Brooklawn
Barrington
Haddonfield
Collingswood
Westmont
Haddon Heights
Lawnside
Magnolia
Audubon
Oaklyn
Merchantville
Pennsauken
Camden
Gloucester
Woodbury
Glassboro
Mantua
Pitman
Washington
Franklin
Deptford
Wenonah
Sewell
Mount Ephraim

X 21-P 4

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2002

(5)

212		8		467
213	Brooklyn Bridge & Blackwell's Island	8		468
214		8		469
215		8		470
216		8		471
217		8		472
218		8		473
219		8		474
220		8		475
221		Newtown Ck	765, 766	476 661
222		"		477
223		"		478
224		"		479
225		"		480
226		"		481
227		8		482
228		8		483
229		8		484
230		8		485
231		8		486
232		8	672, 673	487 641
233		8	670, 671	488
234		8		489 660
235		8		490
236		8		491
237		8		492
238		7	498-500 513-515, 625, 622, 620 602, 656, 657	
239		7	501, 503, 514-512, 628, 630, 693, 695, 657, 660	
240	Battery Section	7	504-505, 519, 521, 631, 633, 696 698 (1)	
246		7	507, 509, 523, 626, 634, 636, 668, 657, 664 661	
242		7	510-512, 525, 527, 637, 639, 652, 654, 654, 659	
243	North North	5		493
244	Hull Section	5		494
245	Lower Bay Control Section	2		495
246	Hudson River 58th St to 79th St	14		496
247	Hudson River Western Section	12	528, 529	497
248		12	530, 531	498
249		12	532, 533	499-A 499-B
250		12		500
251		12	534, 535	501
252		12	536, 537	502
253	Narrows Section	4		503
254		4		504
255		4		505
256		4		506
257	Lower Bay Lunni Section	12		507

X 21 - P. 6

Stations	Chart		Water Samples Nos.	Mud Samples Nos.
258	Lower Bay (Central Section)	2		508
259		2		509
260		2		510
261		2		511
262		2		512
263	Norman's Section	4		513
264	Kill Van Kull Section	5		514
265		5		515
266	Gowanus Section	6		516
267		6		517
268		6		518
269		6		519
270		6		520
271		6		521
272		6		522
273		6		523
274		6		524
275		6		525
276		6		526
277	Narrows Section	4		527
278		4		528
279	Gowanus Section	6		529
280		6		530
281		6		531
282		6		532
283		6		533
284		6		534
285		6		535
286	Hudson River Battery to 57th St	13		536
287		13		537
288		13		538
289		13		539
290	Hudson River New York to Tarrytown	16		540
291		16		541
292		16		542
293	Hudson River 140th St to Spuyten Duyvil	15		543
294		15		544
295		15		545
296		15		546
297		15		547
298	Hudson River 54th St. to 140th St.	14		548
299		14		549
300		14		550
301		14		551
302		14		552
303		14		553

X21-P.7.

304	Hudson River New York to Tarrytown	13		554
305		16		555
306		16		556
307		16		557
308		16		558
309		16		559
310		16		560
311		15		561
312	Hudson River 140th St to Spuyten Duyvil.	15		562
313		15		563
314		15		564
315		15		565
316		15		566
317	East River Section	9		567
318		9		568
319		9		569
320		9		570
321		9		571
322	Brooklyn Bridge to Blackwells Island	8		572
323		8		573
324		8	E. River opp. Standard Oil Slip L.I. City	
325	Lower Bay Central Section	2		575
326		2		576
327		2		577
328		2		578
329		2		579
330		2		580
331		2		581
332		2		582
333		2		583
334	Battery Section	7		584
335		7		585
336	Narrows Section	4		586
337		4		587
338		4		588
339		4		589
340		4		590
341		4		591
342		4		592
343		4		593
344		4		594
345		4		595
346		4		596
347		4		597
348		4		598
349		4		599

X 21-P.8

Station No	Chart		Water Samples Nos	Mud Samples Nos
350	Gowanus Section	6		600
351		6		601
352		6		602
353		6		603
354		6		604
355		6		605
356		6		606
357		6		607
358		6		608
359		6		609
360		6		610
361		6		611
362		6		612
363		6		613
364		6		614
365		6		615
366		6		616
367		6		617
368		6		618
369		6		619
370	Battery Section	7	604	
371	Gowanus Section	6	605, 606	
372		6	607, 608	
373		6	609, 610	
374		6	611, 668, 670	
375		6	612, 644, 667	
376		6	613, 614	
377		4	615, 616	
378	Narrows Section	4	617, 618	
379		4	619, 620	
380		4	621, 622	
381	Lower Bay Central Section	2	623, 624	
382		2		620-632
383		2		623
384		2		624
385		2		625
386		2		626
387		2		627
388		2		628
389		2		629
390		2		630
391		2		631
392		2		632
393		2		633
394		2		634
395		2		635

X21-P9

Station No.	Chart		Master Soundings Nos.	Hand Soundings Nos.
396	Lower Bay Central Section	2		636
397		2		637
398		2		638
399		2		639
400	Lower Bay Eastern Section	8		640
401		7		643
402		7		644
403		7		645
404		6		646
405		6		647
406		3		648
407		3	690, 691	649
408		3	692, 693	650
409		6	694, 695 695	651
410		6	697, 698	652
411		5	699, 700	653
412	Kill Van Kull Section	5	701-703, 715-717	654
413		5	704-706, 718-720	
414		5	707-709, 721-723	
415		5	710-712, 724-726	
416		5	713, 714, 727, 728	655
417	Harlem River Eastern Section	11	729, 730, 737, 738	656
418		11	731-733, 739-741	657
419		11	734-736, 742-744	658
420	Harlem River Western Section	4	745, 746, 756, 755	659
421		4	747-750, 756-759	
422		4	751-753, 760-762	
423	Harlem Ch		763, 764	660
424			767, 768	661
425			775	
426	Harlem River Eastern Section	11	778-780	666
427		11	781-785	667
428		11	786-786	668
429	Harlem River Western Section	12	787-788	
430		12	789-790	669
431		12	791-793	670
432	Pierson Shoal Partridge Rock Hells Gate Bridge & Black Rock Island	13	794-797	
433		18	798-801	
434	Hudson River		802-804 827-829	671
435		"	805-807, 824 826	672
436		"	808-810, 821-823	673
437		"	811-813, 818-820	674
438		"	814-815, 816-817	675
439	Hudson River 180th St to Spuyten Duyvil & Harlem River	15	830, 831, 844, 845	
440		15	832-835, 846-849	676
441		15	836-838, 850 852	677

PROPERTY OF STATE OF NEW YORK DEPT. OF PUBLIC WORKS

402		10	859 - 861, 863 - 866	678
403		10	862, 863; 876, 877	679
404				680 - 682
405	Central Park			683
406				684
407			858, 859	685
408	Greatest Road		860, 861	686
409			862, 863	687
450			864, 868	688
451	Gowanus	6		691
452	Section	6		692
453		6		693
454		6		694
455	Harrison	6		695
456	Section	6		696
457	Gowanus	6		699
458	Section	6		700
459	Harrison	6		701
460	Section	6		702
461	Gowanus	6		703
462	Section	6		704
466		6		705
464		Brooklyn	874, 876	
465		"	877	
466		"	878	
467		"	879	
468		"	880	
469		"	881 - 882	
470		"	883	
471		"	884 - 886	
472		"	887, 1180	
473		"	889	
474		"	890	
475		"	891, 892	
476		"	893, 894	
477		"	895, 896	
478		"	897, 898	
479		"	899	
480		"	900	
481		"	901, 902	
482		"	903	
483			904 - 906	
484			907	
485		Coney Island	908 - 911	
486			882	
487			883	

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 22928

X21-P11.

330 331 336				
329 329 329				

121-P12

1 COMPLAINANTS' EXHIBIT No. 29. James D. Maher, Commissioner.

July 25, 1907.

Franklin Clarkin, Esq., Ass't Secretary City Club of New York, 55 West 44th St., New York City.

DEAR SIR: Referring to your communication of June 5th in which you ask for an opinion based upon the studies of this Commission on river pollution, whether the use of river water as it is, would be undesirable for sprinkling or flushing city streets, we beg to state we understand from this that your inquiry relates to the suitability of water taken from the Hudson or East River for use in sprinkling or flushing the streets of the Borough of Manhattan.

In such case an opinion must take into consideration the pollution of the water to be used as measured by the presence of decomposable organic matter and of bacteria capable of producing disease. These questions have engaged the serious attention of this Commission for a number of months and many hundreds of samples of river and bay water as well as muds deposited therein have been
2 carefully taken and subjected to chemical and biological analyses. The full conclusion to be drawn from this work would at this time be premature and improper. The weight of present evidence may however be stated to indicate strongly the probable inability of the waters of the East and Hudson Rivers and the Upper Bay to assimilate and destroy within a reasonable time the sewage wastes discharged therein. Some of the observations made would no doubt be of present interest to those who are giving the general subject their attention and without in any way emphasizing the relative importance of any particular observation this Commission is willing at this time to announce the results of a series of observations taken along a line projected from the Battery to Jersey Central Railroad Station on the New Jersey shore:—

Bacteria Per C. C. Hudson River Water, Feb. 20, 21, 1907.

Depth.	State of tide.	100′ from Pier "A."	500′ from Pier "A."	¼ way across.	Mid-stream.	¾ way across.	500′ from N. J. C. R.R. Sta.	100′ from N. J. C. R.R. Sta.
1′	Flood..	6350	5850	4550	3800	3400	4550	5850
	Ebb....	7950	6350	3800	3500	3600	1900	3050
20′	Flood..	5200	5100	3800	3500	2850	4050	4750
	Ebb....	6350	5850	3500	3300	3300	5300	8500
40′	Flood..	4050	4550	2400	2400	2150	....	....
	Ebb....	4350	3900	2400	2500	2200	....	....
50′	Flood..	3800	2850	2350	....	....	....	....
	Ebb....	3800	4050	2150	2550	....	....	....

3 These matters relate to the general duties of the Commission in determining the sanitary condition of the waters as a whole rather than to the question raised by the City Club and in order that certain special information required by your inquiry might be available it was decided to make a brief investigation of the biological effect of sprinkling with river water surfaces exposed to the same influences of air, sunlight and shade as would be the City streets under the conditions which you mention. For this purpose samples of North River water were taken at the site of the floating baths at the Battery early in the morning before the baths were opened, the tide being flood about one-half (½) full, the wind southwest and moderate. Two samples A. and B. were taken 20 feet from the Battery Pier, A. being 1 ft. and B. at bottom 15 ft. below the surface. The temperature of the water was 15½ degrees C., the air being 27 degrees C. Both samples had eight points of turbidity, ten points color, about 12,000 parts per million of chlorine representing 2 & sodium chloride and a faint sewage odor. After 48 hours sample A showed 6350 bacteria per C. C. and sample B 4770. Both
4 gave a positive test for B. Coli (intestinal bacteria) in 24 hours.

A sample of sea water was taken from outside of Sandy Hook. This showed 0 points turbidity, 5 points color, 27,000 parts chlorine equivalent to 4.5% sodium chloride, no odor, no bacteria and negative test for B. Coli. A portion of sample A mixed with an equal portion of this sea water, showed after 48 hours 742 bacteria per c. c., while another portion of sample A mixed with an equal amount of distilled water containing 30% sodium chloride (saturated solution) gave after 48 hours only 104 bacteria per c. c. The results of this test indicate the bactericidal effect of relative strong solutions of salt.

Experiments on Samples of Street Dust.

Two samples of street dust were collected on sterile dishes.
A from spot always in sunlight.
B from spot always in shade.
Equal portions of each were added to 500 c. c., sterilized, distilled water and plated. Sample A shows 1,200,000 bacteria per gram and sample B 8,000,000. Both gave positive tests for B. Coli in 1 c. c. and .1 c. c.

Other equal portions of the two samples were then thoroughly wet with sample of river water before mentioned taken from depth 15 ft. The samples of wet dust were then divided, one half of each being places in sunlight and the other half in the shade. At
5 the end of six hours all were dry at which time portions of all were mixed with 500 c. c. sterilized distilled water and plated.

A	exposed in	sunlight	6	hours	showed	440000 bacteria per gram
A	"	" shade	6	"	"	800000
B	"	" sunlight	6	"	"	700000
B	"	" shade	6	"	"	3000000

showing again the bactericidal effect of salt water and the more pronounced bactericidal effect of sunlight. All the above platings showed positive tests for B. Coli in 1 c. c. also in .1 c. c. except samples exposed to sunlight.

Similar tests were made with samples of the dust when sprinkled with the pure strong sea water before referred to and with distilled water containing sodium chloride in saturation.

A	with pure sea water				5	hours	in shade	showed	636000	bacteria per gram
B	"	"	"	"	5	"	"	"	1400000	" "
A	"	saturated sol. nace.			5	hrs.	in shade	"	120000	" "
B	"	"	"	"	5	"	"	"	140000	" "

Confirming the greater bactericidal effect of salt in stronger solutions. All of the above platings showed positive tests for B. Coli in 1 c. c. and .1 c. c. except samples sprinkled with saturated solution of sodium chloride which gave negative tests in both case-.

6

Remarks.

The places and conditions of taking the samples of river water tested were most favorable as it is believed no purer water touches the shores of Manhattan Island than at the Battery during the strong flood of the tide. Although the tests showed conclusively that salt water and sunlight are somewhat inhibitive to the micro-organisms present in polluted water and in street dust it does not appear that the intestinal bacteria are destroyed by the water containing salt in quantities such as obtained in the river and harbor even when combined with exposure to sunlight for periods long enough to dry the dust containing these organisms.

The possible danger to public health from depositing the germs of disease known to exist in sewage wastes upon the streets whence they may be blown about when in a dry state, we do not believe has been sufficiently disposed of by the tests which we have made to permit us to assure you that the use of river water for flushing or sprinkling the City streets in its present state is desirable.

7

It is well known that typhoid bacillus will live from several hours to several days in a dry state depending upon the amount of exposure to the sun. Other bacteria which may be present in sewage polluted river water live for varying lengths of time after drying.

This Commission will continue the foregoing studies at other places along the river fronts of both the Hudson and East Rivers

where the pollution of the water is known to be greater than th samples heretofore tested and will be pleased to advise you furthe with respect to these studies should the results thereof tend in an way to modify the conclusions herein presented.

Yours very truly,

—— ——, *President.*

—— ——, *Secretary.*

COMPLAINANTS' EXHIBIT No. 30. James D. Maher, Commissioner.

Data Abstracted from the Results of the 705 Observations on Harbor Deposits—As Made by the Metropolitan Sewerage Commission Prior to 1908, and as Given in Complainant's Exhibit No. 14.

TABLE No. 1.

Number of Samples Examined at Each Foot of Depth Below the Harbor Bottom.

Depth below harbor bottom.	Surface.	Surface to 1 ft.	1 ft. to 2 ft.	2 ft. to 3 ft.	3 ft. to 4 ft.	4 ft. to 5 ft.	5 ft. to 6 ft.	6 ft. to 7 ft.
Number of samples examined.....	336	13	35	51	48	54	48	36

Depth below harbor bottom.	7 ft. to 8.0	8 ft. to 9.0	9 ft. to 10 ft.	10 ft. to 11 ft.	11 ft. to 12 ft.	12 ft. to 13 ft.	13 ft. to 14 ft.	14 ft. or deeper.
Number of samples examined.....	32	15	9	8	8	4	3	0

TABLE No. 2.

No. of Mud Samples Examined for B. Coli.

	In 1.00 c. c.	In 0.1 c. c.
No. of Samples Examined for B. Coli (Presumptive Test)	275	259
No. of Samples found to contain B. Coli.....	261	227
No. of Samples not found to contain B. Coli.....	14	32

TABLE No. 3.

No. of Samples and Depths at Which B. Coli was Found.

Depths below harbor bottom.	Surface.	Surface to 1 ft.	1 ft. to 2 ft.	2 ft. to 3 ft.	3 ft. to 4 ft.	4 ft. to 5 ft.	5 ft. to 6 ft.	6 ft. to 7 ft.
No. of Samples....	198	1	15	16	10	12	7	2

TABLE No. 4.

Putrescibility of Mud.

No. of Samples Observed for Putrescibility.....	110
" " " " to be Putrescible.....	105
" " " " not to be "	5

TABLE No. 5.

Odors of Various Kinds.

No. of Samples Yielding Each of the Following Odors.

	Faint.	Ordinary.	Strong.	Total
Sewage Odors	24	134	50	208
Sulphureted Hydrogen Odors	..	21	9	30
Gas Odors	3	56	6	65
Petroleum Odors	4	65	7	76
Mouldy Odors	..	7	16	23
Earthy Odors	12	36	..	48
Woody Odors	..	1	..	1
Coal Tar Odors	..	3	2	5
Fishy Odors	2	3	..	5
Aromatic Odors	..	1	..	1
Putrid Odors	..	..	4	4
Burnt Rubber Odors	..	1	1	2
Creosote Odors	..	1	..	1
Odorless Samples	..	..	..	8

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 31.

JAMES D. MAHER,
Commissioner.



Dissolved Oxygen. Kill van Kull Cross-section and Course. June 1, 1909
Low water occurred at Governors Island at 11.5± a.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
35	11.15	20 feet off Columbia Oil Co. pier, Bayonne	Lat 40 39 02 Long 74 05 26	1	Ebb	18	32	5.04	85
36	11.20	20 feet off Columbia Oil Co. pier, Bayonne	Lat 40 39 02 Long 74 05 26	20	Ebb	18	32	5.16	87
37	11.45	Midstream, off Jersey St., New Brighton, S. I.	Lat 40 38 57 Long 74 05 25	1	Ebb	18	32	5.34	90
38	11.55 p.m.	Midstream, off Jersey St., New Brighton, S. I.	Lat 40 38 57 Long 74 05 25	40	Ebb	18	32	5.47	93
39	12.20	20 feet off pier at foot of Jersey St., New Brighton, S. I.	Lat 40 38 51 Long 74 05 24	1	Ebb	18	32	4.75	80
40	12.30	20 feet off pier at foot of Jersey St., New Brighton, S. I.	Lat 40 38 51 Long 74 05 24	10	Ebb	18	32	5.16	87
41	1.40	Midstream, off Port Richmond ferry, S. I.	Lat 40 38 35 Long 74 07 52	1	Flood	18	32	5.34	91
42	2.00	Midstream, off Port Richmond ferry, S. I.	Lat 40 38 35 Long 74 07 52	40	Flood	18	32	5.16	87
43	2.20	Midstream, off Sailors' Snug Harbor, S. I.	Lat 40 38 50 Long 74 06 07	1	Flood	18	32	5.64	96
44	2.30	Midstream, off Sailors' Snug Harbor, S. I.	Lat 40 38 50 Long 74 06 07	40	Flood	17.5	32	5.47	93
45	2.50	20 feet off Columbia Oil Co. pier, Bayonne	Lat 40 39 02 Long 74 05 26	1	Flood	17.5	32	5.64	96
46	3.00	20 feet off Columbia Oil Co. pier, Bayonne	Lat 40 39 02 Long 74 05 26	20	Flood	17.5	32	5.77	98
47	3.10	Midstream, off Jersey St., New Brighton	Lat 40 38 57 Long 74 05 25	1	Flood	17.5	32	5.64	96
48	3.20	Midstream, off Jersey St., New Brighton	Lat 40 38 57 Long 74 05 25	40	Flood	17.6	32	5.77	98
49	3.40	20 feet off pier at foot of Jersey St., New Brighton, S. I.	Lat 40 38 51 Long 74 05 24	1	Flood	17	32	5.34	90
50	4.00	20 feet off pier at foot of Jersey St., New Brighton, S. I.	Lat 40 38 51 Long 74 05 24	10	Flood	17	32	5.47	93

Note- Samples 1-34 covered preliminary studies of the method.

Ex. 31, P. 1.

Complainant's Exhibit No. 31.

James E. Mabey,
Commissioner

Dissolved Oxygen. Harlem River Course. June 2, 1909.

Low water occurred at Governors Island at 12.47 p.m. The wind was east, with a velocity of 8 miles per hour. In the Harlem River the ebb current flows from the East River toward the Hudson River and the flood current from the Hudson River toward the East River.

Sample No.	Hour e.s.t.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Percentage land water	Oxygen: C. C. per litre	Oxygen: Percentage saturation
81	11.40	800 feet east of Spuyten Duyvil drawbridge	Lat 40 52 41 Long 73 56 29	1	Ebb	18	36	4.65	74
82	11.50 a.m.	800 feet east of Spuyten Duyvil drawbridge	Lat 40 52 41 Long 73 56 29	16	Ebb	18	36	4.56	74
83	12.30	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	1	Ebb	18	36	4.65	74
84	12.40	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	20	Ebb	18	36	4.56	76

Ex. 31. P. S.

THE PEOPLE OF THE STATE OF NEW YORK vs.

Low water occurred at Governors Island at 12.47 p.m. The wind was east, with a velocity of 5 miles per hour. In the Harlem River the ebb current flows from the East River toward the Hudson River and the flood current from the Hudson River toward the East River.

Sample No.	Hour p.m.	Location of Samples (proximate)	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C. C. per litre	Oxygen Percent saturation
55	1.20	At Third Ave. bridge, 20 feet from west shore	Lat 40 48 25 Long 73 56 00	1	Ebb	18	36	3.86	89
56	1.25	At Third Ave. bridge, 20 feet from west shore	Lat 40 48 25 Long 73 56 00	20	Ebb	18	36	3.68	81
57	1.35	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 56 57	1	Ebb	18	36	3.86	89
58	1.40	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 56 57	20	Ebb	18	36	3.34	86
59	1.50	At Third Ave. bridge, 20 feet from east shore	Lat 40 48 25 Long 73 56 56	1	Ebb	18	36	3.85	84
60	1.55	At Third Ave. bridge, 20 feet from east shore	Lat 40 48 25 Long 73 56 56	20	Ebb	18	36	3.34	86
61	4.05	At Third Ave. bridge, 20 feet from west shore	Lat 40 48 25 Long 73 56 00	1	Flood	18	36	3.86	84
62	4.10	At Third Ave. bridge, 20 feet from west shore	Lat 40 48 25 Long 73 56 00	20	Flood	18	36	3.98	86
63	4.25	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 56 57	1	Flood	18	36	3.86	84
64	4.30	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 56 57	20	Flood	18	36	3.98	86
65	4.45	At Third Ave. bridge, 20 feet from east shore	Lat 40 48 25 Long 73 56 56	1	Flood	18	36	3.86	89
66	4.50	At Third Ave. bridge, 20 feet from east shore	Lat 40 48 25 Long 73 56 56	20	Flood	18	36	3.34	86

Low water occurred at Governors Island at 1.09 p.m. The wind was north-west, with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C. C. per litre	Oxygen: Percent saturation
67	1.10	Opposite Riverdale, N. Y., 250 feet off New Jersey shore	Lat 40 54 15 Long 73 55 48	1	Ebb	20	72	6.22	100
68	1.15	Opposite Riverdale, N. Y., 250 feet off New Jersey shore	Lat 40 54 15 Long 73 55 48	15	Ebb	20	72	6.08	98
69	1.30	Opposite Riverdale, N. Y., midstream	Lat 40 54 10 Long 73 56 28	1	Ebb	20	72	6.22	100
70	1.35	Opposite Riverdale, N. Y., midstream	Lat 40 54 10 Long 73 56 28	30	Ebb	20	72	6.08	98
71	1.55	Opposite Riverdale, N. Y., 50 feet off Riverdale pier	Lat 40 54 09 Long 73 54 55	1	Ebb	20	72	5.93	96
72	2.00	Opposite Riverdale, N. Y., 50 feet off Riverdale pier	Lat 40 54 09 Long 73 54 55	10	Ebb	20	72	5.77	93
73	3.30	Opposite Riverdale, N. Y., 250 feet off New Jersey shore	Lat 40 54 15 Long 73 55 48	1	Flood	20	72	5.68	91
74	3.40	Opposite Riverdale, N. Y., 250 feet off New Jersey shore	Lat 40 54 15 Long 73 55 48	15	Flood	20	72	5.77	93
75	4.10	Opposite Riverdale, N. Y., midstream	Lat 40 54 10 Long 73 56 28	1	Flood	20	72	5.93	96
76	4.15	Opposite Riverdale, N. Y., midstream	Lat 40 54 10 Long 73 56 28	30	Flood	19.5	72	5.77	93
77	4.35	Opposite Riverdale, N. Y., 50 feet off Riverdale pier	Lat 40 54 09 Long 73 54 55	1	Flood	20	72	5.34	86
78	4.40	Opposite Riverdale, N. Y., 50 feet off Riverdale pier	Lat 40 54 09 Long 73 54 55	10	Flood	20	72	5.47	88

DARK PAGE BLEED

THE PEOPLE OF THE STATE OF NEW YORK v.

Low water occurred at Governors Island at 1.5± p.m. The wind was southeast with a velocity of 30 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
79	12.10	Newark Bay, at C.R.R. of N.J. bridge, 200 feet from east shore	Lat 40 39 17 Long 74 08 27			1	Ebb	21	32	4.18	74
80	12.15	Newark Bay, at C.R.R. of N.J. bridge, 200 feet from east shore	Lat 40 39 17 Long 74 08 27			10	Ebb	21	32	4.21	75
81	12.25	Newark Bay, at C.R.R. of N.J. bridge, near draw	Lat 40 39 19 Long 74 08 46			1	Ebb	21	32	4.43	80
82	12.30	Newark Bay, at C.R.R. of N.J. bridge, near draw	Lat 40 39 19 Long 74 08 46			20	Ebb	21	32	4.56	81
83	12.45	Newark Bay, at C.R.R. of N.J. bridge, 3/4 way across from east shore	Lat 40 39 17 Long 74 09 40			1	Ebb	21	32	4.60	82
84	12.50	Newark Bay, at C.R.R. of N.J. bridge, 3/4 way across from east shore	Lat 40 39 17 Long 74 09 40			10	Ebb	21	32	4.32	77
85	1.25	Passaic River near mouth at C. R. R. of N. J. bridge	Lat 40 43 21 Long 74 07 18			1	Ebb	21.5	31	1.82	31
86	1.30	Passaic River near mouth at C. R. R. of N. J. bridge	Lat 40 43 21 Long 74 07 18			10	Ebb	21.5	32	1.79	31
87	2.00	Passaic River, at foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 56			1	Ebb	22	32	0.63	11
88	2.10	Passaic River, at foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 56			10	Ebb	22	32	0.59	10
89	3.00	Passaic River, at foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 56			1	Flood	22	32	0.70	12
90	3.02	Passaic River, at foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 56			10	Flood	22	32	0.99	17
91	3.40	Passaic River near mouth, at C. R. R. of N. J. bridge	Lat 40 43 21 Long 74 07 18			1	Flood	21	32	3.57	62
92	3.45	Passaic River near mouth, at C. R. R. of N. J. bridge	Lat 40 43 21 Long 74 07 18			10	Flood	21	32	3.65	63

Dissolved Oxygen. Newark Bay Cross-section and Passaic River.(Continued.)June 17,1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent Land water	Oxygen C.C. per litre	Oxygen Percent saturation
93	4.40	Newark Bay, at C.R.R. of N.J.bridge, 200 feet from east shore	Lat 40 39 17 Long 74 08 27	1	Flood	20	28	4.76	83
94	4.45	Newark Bay, at C.R.R. of N.J.bridge, 200 feet from east shore	Lat 40 39 17 Long 74 08 27	10	Flood	20	28	4.86	85
95	4.55	Newark Bay, at C.R.R. of N.J.bridge, near draw	Lat 40 39 17 Long 74 08 46	1	Flood	20	28	5.05	89
96	5.00	Newark Bay, at C.R.R. of N.J.bridge, near draw	Lat 40 39 17 Long 74 08 46	20	Flood	20	28	5.17	91
97	5.10	Newark Bay, at C.R.R. of N.J.bridge, 3/4 way across from east shore	Lat 40 39 17 Long 74 09 40	1	Flood	20	28	5.05	89
98	5.15	Newark Bay, at C.R.R. of N.J.bridge, 3/4 way across from east shore	Lat 40 39 17 Long 74 09 40	10	Flood	20	28	4.86	85

Ex. 31. P. 6.

DARK PAGE BLEED

Dissolved Oxygen. Harlem River Cross-section at East 118 St. June 21, 1909.

Low water occurred at Governors Island at 4.37 p.m. The wind was west with a velocity of 6 miles per hour. In the Harlem River the ebb current flows from the East River to the Hudson River and the flood current from the Hudson River to the East River.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
99	10.30	Opposite East 118 St., 20 feet off Randall Is.	Lat 40 47 40 Long 73 55 40	1	Flood	19	36	2.64	45
100	10.35	Opposite East 118 St., 20 feet off Randall Is.	Lat 40 47 40 Long 73 55 40	20	Flood	19	36	3.18	55
101	10.45	Opposite East 118 St., midstream	Lat 40 47 41 Long 73 55 44	1	Flood	19	36	3.24	56
102	10.50	Opposite East 118 St., midstream	Lat 40 47 41 Long 73 55 44	20	Flood	19	36	2.54	44
103	11.00	20 feet off dock, foot of East 118 St.,	Lat 40 47 43 Long 73 55 48	1	Flood	19	36	2.25	39
104	11.05 p.m.	20 feet off dock, foot of East 118 St.,	Lat 40 47 43 Long 73 55 48	20	Flood	19	36	2.95	51
105	3.20	Opposite East 118 St., 20 feet off Randall Is.	Lat 40 47 40 Long 73 55 40	1	Ebb	19	36	3.50	60
106	3.25	Opposite East 118 St., 20 feet off Randall Is.	Lat 40 47 40 Long 73 55 40	20	Ebb	19	36	4.10	71
107	3.30	Opposite East 118 St., midstream	Lat 40 47 41 Long 73 55 44	1	Ebb	19	36	3.45	60
108	3.35	Opposite East 118 St., midstream	Lat 40 47 41 Long 73 55 44	20	Ebb	19	36	3.11	54
109	3.40	20 feet off dock, foot of East 118 St.,	Lat 40 47 43 Long 73 55 48	1	Ebb	19	36	3.35	58
110	3.45	20 feet off dock, foot of East 118 St.	Lat 40 47 43 Long 73 56 48	20	Ebb	19	36	3.70	64

Dissolved Oxygen. East River Cross-section between Lawrence Point and Stony Point.
June 21, 1909.

Low water occurred at Governors Island at 4.37 p.m. The wind was west, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
111	11.55	20 feet off dock at Lawrence Pt.	Lat 40 47 25 Long 73 54 35	1	Flood	19	32	3.30	57
112	12.00 p.m.	20 feet off dock at Lawrence Pt.	Lat 40 47 25 Long 73 54 35	20	Flood	19	32	3.20	55
113	12.10	Midstream, off Lawrence Point	Lat 40 47 45 Long 73 54 31	1	Flood	19	32	3.82	66
114	12.15	Midstream, off Lawrence Point	Lat 40 47 45 Long 73 54 31	70	Flood	19	32	3.62	62
115	12.25	20 feet off ferry slip, Stony Pt.	Lat 40 47 57 Long 73 54 31	1	Flood	19	32	3.58	62
116	12.30	20 feet off ferry slip, Stony Pt.	Lat 40 47 57 Long 73 54 31	40	Flood	19	32	4.12	71
117	4.05	20 feet off dock at Lawrence Pt.	Lat 40 47 25 Long 73 54 35	1	Ebb	18	32	4.42	76
118	4.10	20 feet off dock at Lawrence Pt.	Lat 40 47 25 Long 73 54 35	20	Ebb	18	32	4.34	75
119	4.15	Midstream, off Lawrence Point	Lat 40 47 45 Long 73 54 31	1	Ebb	18	32	4.92	85
120	4.20	Midstream, off Lawrence Point	Lat 40 47 45 Long 73 54 31	70	Ebb	18	32	4.72	81
121	4.25	20 feet off ferry slip, Stony Pt.	Lat 40 47 57 Long 73 54 31	1	Ebb	18	32	4.04	70
122	4.30	20 feet off ferry slip, Stony Pt.	Lat 40 47 57 Long 73 54 31	40	Ebb	18	32	4.12	71

DARK PAGE BLEED

High water occurred at Governors Island at 12.20 p.m. The wind was south, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact:	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
123	11.00	50 feet off west dock, Throgs Neck	Lat	40	48	19	1	Flood	18.5	28	5.16	88
			Long	73	47	45						
124	11.05	50 feet off west dock, Throgs Neck	Lat	40	48	19	30	Flood	18.5	28	5.05	86
			Long	73	47	45						
125	11.20	1/4 way across river from Throgs Neck	Lat	40	48	12	1	Flood	18.5	28	5.47	93
			Long	73	47	48						
126	11.25	1/4 way across river from Throgs Neck	Lat	40	48	12	40	Flood	18.0	28	5.34	91
			Long	73	47	48						
127	11.40	1/2 way across river from Throgs Neck	Lat	40	48	04	1	Flood	18.5	28	5.77	98
			Long	73	47	52						
128	11.45	1/2 way across river from Throgs Neck	Lat	40	48	04	70	Flood	18.0	28	5.65	96
			Long	73	47	52						
129	12.00 p.m.	3/4 way across river from Throgs Neck	Lat	40	47	51	1	Flood	18.5	28	5.77	98
			Long	73	47	56						
130	12.05	3/4 way across river from Throgs Neck	Lat	40	47	51	40	Flood	18.0	28	5.65	96
			Long	73	47	56						
131	12.20	50 feet off dock at Beechhurst, L.I., west of Willets Point	Lat	40	47	48	1	Flood	18.5	28	5.16	88
			Long	73	48	00						
132	12.25	50 feet off dock at Beechhurst, L.I., west of Willets Point	Lat	40	47	48	20	Flood	18.0	28	5.34	91
			Long	73	48	00						
133	3.05	50 feet off west dock, Throgs Neck	Lat	40	48	19	1	Ebb	18.5	28	6.08	103
			Long	73	47	45						
134	3.10	50 feet off west dock, Throgs Neck	Lat	40	48	19	30	Ebb	18.0	28	5.93	101
			Long	73	47	45						
135	3.25	1/4 way across river from Throgs Neck	Lat	40	48	12	1	Ebb	18.5	28	6.08	103
			Long	73	47	48						

THE STATE OF NEW JERSEY ET AL. 6279

ED THRU

Dissolved Oxygen. East River Cross-section at Throgs Neck. (Continued.) June 23, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C. C. per litre	Oxygen: Percent saturation
136	3.30	1/4 way across river from Throgs Neck	Lat 40 48 12 Long 73 47 48	40	Ebb	18.0	28	5.93	101
137	3.45	1/2 way across river from Throgs Neck	Lat 40 48 04 Long 73 47 52	1	Ebb	18.5	28	6.38	108
138	3.50	1/2 way across river from Throgs Neck	Lat 40 48 04 Long 73 47 52	70	Ebb	18.0	28	6.23	106
139	4.05	3/4 way across river from Throgs Neck	Lat 40 47 51 Long 73 47 56	1	Ebb	18.5	28	5.93	101
140	4.10	3/4 way across river from Throgs Neck	Lat 40 47 51 Long 73 47 56	40	Ebb	18.0	28	5.65	96
141	4.25	50 feet off dock at Beechhurst, L.I. west of Willet's Point	Lat 40 47 48 Long 73 48 00	1	Ebb	18.5	28	6.08	103
142	4.30	50 feet off dock at Beechhurst, L.I. west of Willet's Point	Lat 40 47 48 Long 73 48 00	20	Ebb	18.5	28	5.93	101

Ex. 31. P. 10.

DARK PAGE BLEED

High water occurred at Governors Island at 1.23 p.m. The wind was west, with a velocity of 5 miles per hour

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C. C. per litre	Oxygen: Percent saturation
143	10.00	50 feet off Fort Wadsworth	Lat 40 36 21 Long 74 03 13	1	Flood	19.0	20	5.34	95
144	10.05	50 feet off Fort Wadsworth	Lat 40 36 21 Long 74 03 13	40	Flood	18.0	20	5.25	94
145	10.20	1/4 way across Narrows, from Fort Wadsworth	Lat 40 36 23 Long 74 03 02	1	Flood	19.0	20	5.47	98
146	10.25	1/4 way across Narrows, from Fort Wadsworth	Lat 40 36 23 Long 74 03 02	60	Flood	18.0	20	5.34	95
147	10.40	1/2 way across Narrows,	Lat 40 36 25 Long 74 02 48	1	Flood	19.0	20	5.82	104
148	10.45	1/2 way across Narrows,	Lat 40 36 25 Long 74 02 48	60	Flood	18.0	20	5.49	98
149	11.00	3/4 way across Narrows, from Fort Wadsworth	Lat 40 36 27 Long 74 02 34	1	Flood	19.0	20	5.77	103
150	11.05	3/4 way across Narrows, from Fort Wadsworth	Lat 40 36 27 Long 74 02 34	60	Flood	18.0	20	5.54	96
151	11.20	50 feet off Fort Lafayette, east shore	Lat 40 36 29 Long 74 02 23	1	Flood	19.0	20	5.64	101
152	11.25 p.m.	50 feet off Fort Lafayette, east shore	Lat 40 36 29 Long 74 02 23	10	Flood	19.0	20	5.77	103
153	3.20	50 feet off Fort Wadsworth,	Lat 40 36 21 Long 74 03 13	1	Ebb	20.5	28	4.72	84
154	3.25	50 feet off Fort Wadsworth,	Lat 40 36 21 Long 74 03 13	40	Ebb	18.0	28	4.15	70
155	3.40	1/4 way across Narrows, from Fort Wadsworth	Lat 40 36 23 Long 74 03 02	1	Ebb	20.5	28	4.60	82
156	3.45	1/4 way across Narrows, from Fort Wadsworth	Lat 40 36 23 Long 74 03 02	60	Ebb	18.0	28	3.64	62

THE STATE OF NEW JERSEY ET AL. 1921

FEED THRU

Dissolved Oxygen. The Narrows Cross-section at the Narrows. (Continued.)
June 24, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C. Q. per litre	Oxygen Percent saturation
157	4.00	1/2 way across Narrows	Lat 40 36 25 Long 74 02 48	1	Ebb	20.5	28	4.96	80
158	4.05	1/2 way across Narrows	Lat 40 36 25 Long 74 02 48	60	EBB	18.0	28	3.95	67
159	4.20	3/4 way across Narrows, from Fort Wadsworth	Lat 40 36 27 Long 74 02 34	1	Ebb	20.5	28	5.11	91
160	4.25	3/4 way across Narrows, from Fort Wadsworth	Lat 40 36 27 Long 74 02 34	60	Ebb	18.0	28	4.15	70
161	4.40	50 feet off Fort Lafayette, east shore	Lat 40 36 29 Long 74 02 23	1	Ebb	20.5	28	4.60	82
162	4.45	50 feet off Fort Lafayette, east shore	Lat 40 36 29 Long 74 02 23	10	Ebb	20.0	28	4.45	80

Ex. 31. P. 12.

DARK PAGE BLE

High water occurred at Governors Island at 8.0b p.m. The wind was west, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
163	9.45	50 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	20.5	28	4.08	75
164	9.48	50 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Flood	19.5	28	4.25	75
165	10.00	1/4 way across East River from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Flood	20.5	28	4.45	80
166	10.05	1/4 way across East River from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Flood	19.0	28	4.08	70
167	10.20	1/2 way across East River	Lat 40 42 03 Long 74 00 11	1	Flood	20.5	28	4.37	78
168	10.25	1/2 way across East River	Lat 40 42 03 Long 74 00 11	40	Flood	19.0	28	3.95	68
169	10.40	3/4 way across East River from pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	1	Flood	20.5	28	4.15	74
170	10.45	3/4 way across East River from pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	40	Flood	19.0	28	3.79	65
171	11.00	50 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Flood	20.5	28	3.79	68
172	11.05	50 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	40	Flood	19.0	28	3.65	63
173	p.m. 2.55	50 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	21.0	28	3.26	59
174	3.00	50 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Ebb	20.0	28	2.43	43
175	3.15	1/4 way across East River from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Ebb	21.0	28	3.80	64

THE STATE OF NEW JERSEY ET AL. v. 8285

ED THRU

Dissolved Oxygen. East River Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. (Continued.) June 25, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
176	3.20	1/4 way across East River from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Ebb	20.0	28	2.97	82
177	3.35	1/2 way across East River	Lat 40 42 03 Long 74 00 11	1	Ebb	21.0	28	3.86	69
178	3.40	1/2 way across East River	Lat 40 42 03 Long 74 00 11	40	Ebb	20.0	28	2.97	82
179	3.55	3/4 way across East River from pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	1	Ebb	21.0	28	3.83	70
180	4.00	3/4 way across East River from pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	40	Ebb	20.0	28	3.11	88
181	4.15	50 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Ebb	21.0	28	3.96	65
182	4.20	50 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	40	Ebb	20.0	28	2.67	47

Ex. 31. P. 14.

DARK PAGE BLE

THE PEOPLE OF THE STATE OF NEW YORK vs.

High water occurred at Governors Island at 8.08 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
183	11.35	At Vernon Ave. bridge	Lat 40 44 21 Long 73 57 20	1	Flood	25.5	32	0.00	0.
184	11.45	At Greenpoint Ave. bridge	Lat 40 44 00 Long 73 56 30	1	Flood	25.5	32	0.00	0
185	11.55	At Meeker Ave. bridge	Lat 40 43 40 Long 73 55 00	1	Flood	25.5	32	0.00	0

Ex. 31. P. 10.

THE STATE OF NEW JERSEY ET AL.

ED THRU

Dissolved Oxygen. Wallabout Canal. June 30, 1909.

High water occurred at Governors Island at 2.03 p.m.

Sample No.	Hour p.m.	Location of Sample — Approximate	Lat/Long	°	'	°	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
186	1.20	In Canal near Wallabout Market	Lat	40	41	12	1	Flood	25.0	22	0.30	6
			Long	73	58	00						

Re. 31. P. 16.

THE PUBLIC OF THE STATE OF NEW YORK 1909

DARK PAGE BLEED

Rise water occurred at Governors Island at 2.58 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Remote			Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	Oxygen: C. C. per litre	Oxygen: Percent saturation
187	10.08	Gowanus Canal, at 9 St. bridge	Lat	40	40	25	1	Ebb	25.5	28	0.00	0
			Long	73	59	50						
189	10.38	Gowanus Canal, at Hamilton Ave. bridge	Lat	40	40	17	1	Ebb	25.5	28	0.00	0
			Long	73	59	54						
189	10.58	Gowanus Bay, at entrance to canal	Lat	40	39	56	1	Ebb	24.0	28	1.36	20
			Long	74	00	25						
190	11.15	Gowanus Bay at outer end	Lat	40	39	40	1	Ebb	23.5	28	2.64	37
			Long	74	01	00						
191	11.36	By spar buoy off Gowanus Bay	Lat	40	39	45	1	Ebb	21.0	28	2.86	41
			Long	74	01	10						

Rm. 21. P. 17.

THE STATE OF NEW JERSEY ET AL.

FEED THRU

Dissolved Oxygen. Wallabout Bay. June 28, 1909.

High water occurred at Governors Island at 4.17 p. m. The wind was north-west, with a velocity of 10 miles per hour.

Sample a.m.	Hour p.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
192	1.08	Near sewer outlet, foot Division Ave., Wallabout Bay	Lat	40 42 20		1	Flood	25.0	70	0.00	0
			Long	73 58 15							
193	1.20	Near sewer outlet, foot Division Ave., Wallabout Bay	Lat	40 42 20		10	Flood	21.0	40	8.08	87
			Long	73 58 15							
194	1.45	100 feet off foot of 11 St. Wallabout Bay	Lat	40 42 25		1	Flood	21.0	40	0.61	11
			Long	73 58 15							
195	1.58	100 feet off foot of 11 St. Wallabout Bay	Lat	40 42 25		10	Flood	20.5	40	2.43	43
			Long	73 58 15							
196	2.10	Outer end of Wallabout Bay, junction with East River	Lat	40 42 30		1	Flood	20.5	40	1.17	21
			Long	73 58 15							
197	2.40	Outer end of Wallabout Bay, junction with East River	Lat	40 42 30		10	Flood	19.5	32	3.64	64
			Long	73 58 15							
198	3.20	East River under Williamsburg bridge, 100 feet from Brooklyn shore	Lat	40 42 45		1	Flood	19.5	32	3.86	69
			Long	73 58 10							
199	3.38	East River, under Williamsburg bridge, 100 feet from Brooklyn shore	Lat	40 42 45		10	Flood	19.0	32	3.98	69
			Long	73 58 10							

Rs. 31. P. 19.

DARK PAGE BL

Dissolved Oxygen. Rockaway Inlet Cross-section. June 19, 1909.

High water occurred at Governors Island at 8.13 p.m. The wind was north-west with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Lat. / Long.	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percentage saturation
200	12.50	80 feet off dock at Rockaway Pt.	Lat 40 34 05 / Long 73 53 80	1	Ebb	20.8	16	5.31	97
201	1.10	80 feet off dock at Rockaway Pt.	Lat 40 34 05 / Long 73 53 80	20	Ebb	20.8	16	5.31	97
202	1.20	Half-way across inlet	Lat 40 34 15 / Long 73 53 58	1	Ebb	20.5	16	5.04	92
203	1.30	Half-way across inlet	Lat 40 34 15 / Long 73 53 58	40	Ebb	20.5	16	5.17	94
204	1.40	By gas buoy 2 at west side of inlet	Lat 40 34 20 / Long 73 54 08	1	Ebb	20.8	16	4.81	88
205	1.50	By gas buoy 2 at west side of inlet	Lat 40 34 20 / Long 73 54 08	18	Ebb	20.8	16	4.93	90

Ex. 31. P. 19.

BLEED THRU

THE STATE OF NEW JERSEY ET AL.

High water occurred at Governors Island at 5.15 p.m. The wind was north-west with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Temp. land	Percent water	Oxygen: C.C. per litre	Oxygen: Percent saturation
206	2.15	100 feet off dock at Belle Harbor	Lat 40 34 55 Long 73 51 05	1	Flood	21.5		16	6.04	93
207	2.30	100 feet off dock at Belle Harbor	Lat 40 34 55 Long 73 51 05	10	Flood	21.5		16	5.17	96
208	3.05	100 feet off dock at Seaside, Rockaway Beach	Lat 40 35 10 Long 73 49 35	1	Flood	22.5		20	4.15	78
209	3.15	100 feet off dock at Seaside, Rockaway Beach	Lat 40 35 10 Long 73 49 35	10	Flood	22.5		20	4.56	86
210	3.35	At drawbridge near Hammel's Station	Lat 40 35 45 Long 73 48 50	1	Flood	23.0		20	4.15	80
211	3.45	At drawbridge near Hammel's Station	Lat 40 35 45 Long 73 48 50	10	Flood	22.5		20	4.25	80
212	5.00	Foot of Bayswater Ave., Far Rockaway	Lat 40 36 30 Long 73 46 15	1	Flood	23.0		24	4.15	80
213	5.20	By bridge at head of Norton's Creek	Lat 40 36 00 Long 73 46 10	1	Flood	27.0		28	3.86	77

DARK PAGE BL

3290 THE PEOPLE OF THE STATE OF NEW YORK VS

Low water occurred at Governors Island at 11.57 a. m. The wind was north-west, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
214	7.30	At bridge, head of Norton's Creek	Lat 40 36 00 Long 73 45 10	1	Ebb	27.0	28	3.26	65
215	7.50	Foot Bayswater Ave., Far Rockaway	Lat 40 36 15 Long 73 46 10	1	Ebb	25.0	28	3.86	74
216	8.30	Increek near Arverne Station	Lat 40 35 40 Long 73 47 25	1	Ebb	27.0	28	0.00	00
217	9.50	In same creek, 1000 feet from shore	Lat 40 36 05 Long 73 47 20	1	Ebb	25.0	28	3.26	63
218	10.20 p.m.	Cross-channel off Arverne parallel to Beach Channel	Lat 40 35 50 Long 73 48 25	1	Ebb	25.0	28	3.26	63
219	1.10	100 feet off foot Bannister Ave., Arverne, near sewer outlet	Lat 40 35 45 Long 73 48 15	1	Flood	25.0	28	0.29	6
220	1.40	Foot of Pleasant St., Arverne	Lat 40 36 35 Long 73 48 25	1	Flood	27.0	28	1.48	30
221	2.20	Foot of Park Ave. Arverne	Lat 40 36 30 Long 73 48 20	1	Flood	27.0	28	1.48	30
222	3.05	Front yard of house near foot of Pleasant Ave.	Lat 40 36 35 Long 73 48 10	1	Flood	27.0	28	1.19	24

FILED IN THE SUPREME COURT OF THE STATE OF NEW JERSEY ET AL.
1929
FOLDED THRU

Dissolved Oxygen. Jamaica Bay. July 1, 1909.

Low water occurred at Governors Island at 12.37 p.m. The wind was south-west with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
223	8.25	Fresh Creek, at mouth	Lat 40 38 30 Long 73 52 55	1	Ebb	25.0	28	2.97	57
224	9.10	Fresh Creek, half-way up	Lat 40 38 50 Long 73 53 20	1	Ebb	25.0	28	2.97	57
225	9.50	Fresh Creek, 200 yards below Railroad crossing	Lat 40 39 15 Long 73 53 45	1	Ebb	25.5	28	2.67	51
226	10.45	Second Creek, near sewer outlet	Lat 40 39 05 Long 73 53 00	1	Ebb	26.0	28	0.00	0
227	11.05	Second Creek, at mouth	Lat 40 38 55 Long 73 52 40	1	Ebb	25.5	28	0.59	12
228	11.35	Jamaica Bay, 500 feet off mouth of Second Creek	Lat 40 38 35 Long 73 52 25	1	Ebb	25.5	28	1.19	23
229	12.00 p.m.	Jamaica Bay, 500 feet off mouth of Fresh Creek	Lat 40 38 25 Long 73 52 30	1	Ebb	25.5	28	2.08	41
230	12.50	Jamaica Bay, 500 feet off Sandy Bay shore	Lat 40 37 50 Long 73 53 05	1	Flood	25.0	20	2.67	53
231	1.20	Creek running back through Canarsie	Lat 40 38 15 Long 73 54 00	1	Flood	25.0	20	3.56	71
232	1.45	Jamaica Bay, 100 feet off main landing, Canarsie	Lat 40 37 40 Long 73 53 15	1	Flood	24.0	20	4.15	80
233	2.05	Jamaica Bay, 200 feet off Bath Pool, Bergen Beach	Lat 40 37 00 Long 73 53 45	1	Flood	24.0	20	4.75	91

THE PEOPLE OF THE STATE OF NEW YORK vs.
7972
DARK PAGE BL

Dissolved Oxygen. Rockaway Inlet Cross-section. July 1, 1909.

High water occurred at Governors Island at 5.47 p.m. The wind was south-west, with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
234	2.45	50 feet off dock at Rockaway Pt.	Lat 40 34 05 Long 73 53 50	1	Flood	19.0	8	5.93	108
235	2.50	50 feet off dock at Rockaway Pt.	Lat 40 34 05 Long 73 53 50	20	Flood	19.0	8	6.08	111
236	3.05	Half-way across inlet	Lat 40 34 15 Long 73 53 55	1	Flood	19.0	8	6.23	113
237	3.10	Half-way across inlet	Lat 40 34 15 Long 73 53 55	40	Flood	19.0	8	6.18	112
238	3.25	By gas buoy 2 at west side of inlet	Lat 40 34 20 Long 73 54 05	1	Flood	19.0	8	6.18	112
239	3.30	By gas buoy 2 at west side of inlet	Lat 40 34 20 Long 73 54 05	10	Flood	19.0	8	6.23	113

Ex. 31. P. 23.

LEED THRU

THE STATE OF NEW JERSEY VS.

Dissolved Oxygen. Harlem River at 118 St. July 2, 1909.

Low water occurred at Governors Island at 1.23 p.m. The wind was west, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
240	10.30	Harlem River, midstream off East 118 St.	Lat 40 47 41 Long 73 56 44	1	Ebb	20.0	28	2.22	39
241	10.40	Harlem River, midstream off East 118 St.	Lat 40 47 41 Long 73 56 44	20	Ebb	20.0	28	2.37	42

Ex. 31. P. 24

DARK PAGE BLE

Low water occurred at Governors Island at 1.23 p.m. The wind was west, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples. Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
242	11.00	East River, midstream, opposite East 92St.	Lat 40 46 50 Long 73 56 25	1	Ebb	19.5	28	2.91	51
243	11.10	East River, midstream, opposite East 92 St.	Lat 40 46 50 Long 73 56 25	30	Ebb	19.0	28	3.04	52
244	11.20	East River, midstream, opposite East 92 St.	Lat 40 46 50 Long 73 56 25	60	Ebb	18.0	28	3.60	59
245	11.40	East River, off East 80St.	Lat 40 45 10 Long 73 56 50	1	Ebb	19.5	28	2.91	51
246	11.50	East River, off East 80St.	Lat 40 46 10 Long 73 56 50	60	Ebb	18.0	28	3.34	57
247	12.10 p.m.	East River, at Queensboro bridge West channel, midstream,	Lat 40 45 25 Long 73 57 30	1	Ebb	19.5	28	3.26	57
248	12.20	East River, at Queensboro bridge west channel, midstream,	Lat 40 45 25 Long 73 57 30	35	Ebb	19.0	28	3.34	58
249	12.30	East River, at Queensboro bridge west channel, midstream	Lat 40 45 25 Long 73 57 30	70	Ebb	18.0	28	3.60	59
250	12.50	East River, midstream, opposite East 42 St.	Lat 40 44 50 Long 73 57 55	1	Ebb	19.5	28	3.26	57
251	1.05	East River, midstream, opposite East 42 St.	Lat 40 44 50 Long 73 57 55	40	Ebb	18.5	28	3.50	59
252	1.25	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	1	Ebb	19.5	28	3.20	56
253	1.35	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	20	Ebb	19.0	28	3.04	52
254	1.45	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	40	Ebb	18.5	28	3.26	55

THE STATE OF NEW JERSEY ET AL. 1956

Dissolved Oxygen. East River Course from Hell Gate to Brooklyn Bridge.

(Continued.) July 2, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
255	2.05	East River, midstream, at Williamsburg bridge	Lat 40 42 49 Long 73 58 21	1	Ebb	19.0	28	3.26	57
256	2.15	East River, midstream, at Williamsburg bridge	Lat 40 42 49 Long 73 58 21	40	Ebb	18.0	28	3.34	57
257	2.50	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	1	Slack	19.0	28	3.20	56
258	3.05	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	20	Slack	19.0	28	3.34	58
259	3.20	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	40	Slack	18.5	28	3.86	65

Kr. 31. P. 26.

THE PEOPLE OF THE STATE OF NEW YORK V.

DARK PAGE BLE

Low water occurred at Governors Island at 2.27 p.m. The wind was north-west, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
260	8.30	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	1	Flood	19.0	20	4.08	72
261	8.35	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	20	Flood	19.0	20	4.15	73
262	8.40	East River, midstream, at Brooklyn bridge	Lat 40 42 20 Long 73 59 48	40	Flood	18.5	20	4.25	73
263	8.50	East River, midstream, at Williamsburg bridge	Lat 40 42 49 Long 73 58 21	1	Flood	19.0	20	3.79	67
264	8.55	East River, midstream, at Williamsburg bridge	Lat 40 42 49 Long 73 58 21	40	Flood	18.5	20	4.15	71
265	9.05	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	1	Flood	19.0	20	3.79	68
266	9.10	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	20	Flood	19.0	20	3.56	62
267	9.15	East River, midstream, opposite East 23 St.	Lat 40 44 00 Long 73 58 05	40	Flood	18.0	20	4.25	73
268	9.25	East River, midstream, opposite East 42 St.	Lat 40 44 50 Long 73 57 55	1	Flood	19.0	20	3.86	68
269	9.30	East River, midstream, opposite East 42 St.	Lat 40 44 50 Long 73 57 55	40	Flood	18.0	20	3.95	68
270	9.40	East River, midstream, west channel at Queensboro bridge	Lat 40 45 25 Long 73 57 30	1	Flood	19.0	20	3.56	62
271	9.45	East River, midstream, west channel at Queensboro bridge	Lat 40 45 25 Long 73 57 30	30	Flood	19.0	20	3.95	68
272	9.50	East River, midstream, west channel at Queensboro bridge	Lat 40 45 25 Long 73 57 30	70	Flood	18.0	20	4.08	70

THE STATE OF NEW JERSEY ET AL.
vs.
SPEED THRU

Dissolved Oxygen. East River: Course from Brooklyn Bridge to Hell Gate.

(Continued.) July 3, 1909.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
273	10.00	East River, opposite East 80 St.	Lat 40 46 10 Long 73 56 50	1	Flood	19.0	20	3.26	58
274	10.05	East River, opposite East 80 St.	Lat 40 46 10 Long 73 56 50	60	Flood	18.0	20	3.34	58
275	10.15	East River, midstream, opposite East 92 St.	Lat 40 46 50 Long 73 56 25	1	Flood	19.0	20	3.80	63
276	10.20	East River, midstream, opposite East 92 St.	Lat 40 46 50 Long 73 56 25	30	Flood	18.6	20	3.26	57
277	10.25	East River, midstream, opposite East 92 St.	Lat 40 46 50 Long 73 56 25	60	Flood	18.0	20	3.67	63

Ex. 31. P. 28

DARK PAGE BLEED

High water occurred at Governors Island at 11.18 a.m. The wind was east, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent atura-tion
278	11.40	Opposite Mt. St. Vincent, 100 feet off shore	Lat 40 54 50 Long 73 54 41	1	Flood	20.6	64	4.76	79
279	12.00 p.m.	Opposite Mt. St. Vincent, 100 feet off shore	Lat 40 54 50 Long 73 54 41	8	Flood	20.8	64	4.86	76
280	12.20	Opposite Ludlow's Station, 200 feet off shore	Lat 40 55 35 Long 73 54 30	1	Flood	20.8	64	4.76	79
281	12.30	Opposite Ludlow's Station, 200 feet off shore	Lat 40 55 35 Long 73 54 30	10	Flood	20.8	64	4.25	71
282	12.50	Opposite Sugar Refinery, Yonkers 200 feet off shore	Lat 40 55 47 Long 73 54 25	1	Flood	20.5	64	4.45	74
283	1.00	Opposite Sugar Refinery, Yonkers 200 feet off shore	Lat 40 55 47 Long 73 54 25	10	Flood	20.5	64	3.95	66
284	1.20	Opposite recreation pier, Yonkers, 200 feet off shore	Lat 40 56 18 Long 73 54 20	1	Flood	21.0	64	3.86	64
285	1.30	Opposite recreation pier, Yonkers, 200 feet off shore	Lat 40 56 18 Long 73 54 20	20	Flood	20.8	64	3.64	61
286	3.00	Opposite Mt. St. Vincent, 100 feet off shore	Lat 40 54 50 Long 73 54 41	1	Ebb	21.0	68	3.86	63
287	3.30	Opposite Mt. St. Vincent, 100 feet off shore	Lat 40 54 50 Long 73 54 41	8	Ebb	21.0	68	3.64	60
288	3.50	Opposite Riverdale, 200 feet off shore	Lat 40 54 10 Long 73 54 55	1	Ebb	21.0	68	3.86	63
289	4.00	Opposite Riverdale, 200 feet off shore	Lat 40 54 10 Long 73 54 55	10	Ebb	21.0	68	3.64	60
290	4.20	Opposite Spuyten Duyvil 200 feet off drawbridge	Lat 40 53 50 Long 73 55 15	1	Ebb	21.0	68	3.54	58

FOLDED THRU
THE STATE OF NEW JERSEY ET AL.
vs.
1918

Dissolved Oxygen. Hudson River Course from Mt. St. Vincent to Yonkers.

(Continued.) July 7, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate		Knapt s	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percentage
291	4.20	Opposite Spuyten Duyvil	Lat	40	52	40	10	Ebb	21.0	68	5.34	88
		200 feet off drawbridge	Long	73	55	25						
292	4.50	Opposite Inwood station	Lat	40	51	20	1	Ebb	21.0	68	5.71	61
		200 feet off shore	Long	73	55	50						
293	5.00	Opposite Inwood station	Lat	40	51	20	10	Ebb	21.0	68	5.34	88
		200 feet off shore	Long	73	55	50						

Rm. 21. P. 30.

THE PEOPLE OF THE STATE OF NEW YORK v.
1909

DARK PAGE BL

High water occurred at Governors Island at 1.00 p.m. The wind was south-east, with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
294	12.30	Gravesend Bay, 200 feet off Marine Basin	Lat 40 36 10 Long 74 00 00	1	Flood	20.6	12	5.24	99
295	12.40	Gravesend Bay, 200 feet off Marine Basin	Lat 40 36 10 Long 74 00 00	10	Flood	20.6	12	5.47	101
296	1.00	Gravesend Bay, 200 feet off Atlantic Yacht Club	Lat 40 35 38 Long 74 00 00	1	Flood	20.6	12	5.24	99
297	1.10	Gravesend Bay, 200 feet off Atlantic Yacht Club	Lat 40 35 38 Long 74 00 00	10	Flood	20.6	12	5.77	107
298	1.30	Coney Island Creek, at mouth	Lat 40 34 48 Long 73 59 10	1	Flood	20.6	12	1.78	33
299	2.18	Coney Island Creek, foot of 12 St., Coney Island	Lat 40 34 55 Long 73 58 58	1	Ebb	21.0	12	3.96	73
300	3.10	Coney Island Creek, foot of 17 St., Coney Island	Lat 40 34 55 Long 73 59 08	1	Ebb	21.0	12	3.96	73
301	3.40	Gravesend Bay, foot of 22 St., Coney Island	Lat 40 34 50 Long 73 59 33	1	Ebb	22.0	12	0.59	11
302	4.20	Gravesend Bay, foot of 24 St., Coney Island	Lat 40 34 48 Long 73 59 40	1	Ebb	21.8	12	1.19	22
303	5.00	Gravesend Bay, 200 feet off Atlantic Yacht Club	Lat 40 35 38 Long 74 00 00	1	Ebb	20.8	12	3.84	72

FILED THEREIN

FROM STATE OF NEW JERSEY ET AL.

1911

Dissolved Oxygen. Gravesend Bay. July 10, 1909.

High water occurred at Governors Island at 7.11 p.m. The wind was south-west, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
304	9.45	Off Ulmer Park, end of dock	Lat 40 35 18 Long 73 59 50	1	Flood	19.0	12	4.48	81
305	10.15	Off Bay Yacht Club, end of dock	Lat 40 36 10 Long 74 00 55	1	Flood	19.0	12	4.48	81
306	10.40	800 feet off Avon Beach Hotel	Lat 40 36 00 Long 74 00 20	1	Flood	19.0	12	4.78	86
307	11.10	100 feet off Fort Lowry Hotel dock	Lat 40 35 50 Long 74 00 10	1	Flood	19.0	12	4.78	86
308	11.50	Outer end of Marine Basin	Lat 40 34 10 Long 74 01 06	1	Flood	19.0	12	5.04	92
309	12.20 p.m.	By breakwater north of Coney Island Creek	Lat 40 35 00 Long 73 59 30	1	Flood	19.0	12	4.48	81
310	1.08	Foot 22 St., Coney Island	Lat 40 34 50 Long 73 59 30	1	Flood	19.0	12	1.19	21

Ex. 31. P. 38.

DARK PAGE BLOCK

THE REGENTS OF THE STATE OF NEW YORK v.

Dissolved Oxygen. The Narrows. July 30, 1909.

High water occurred at Governors Island at 2.11 p.m. The wind was southeast, with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen — C. C. per litre	Oxygen — Percent saturation
311	1.30	Narrows, near Fort Lafayette	Lat 40 36 29 Long 74 02 28	1	Flood	19.0	12	5.34	97
312	1.40	Narrows, near Fort Lafayette	Lat 40 36 29 Long 74 02 28	40	Flood	19.0	12	5.04	92
313	2.00	Narrows, near Fort Lafayette	Lat 40 36 29 Long 74 02 28	90	Flood	18.5	12	4.78	85

Ex. 31. P. 30.

THE STATE OF NEW JERSEY ET AL. v. 2005

EED THRU

Dissolved Oxygen. Sandy Hook Bay and Shrewsbury River. July 13, 1909.

High water occurred at Governors Island at 5.13 p.m. The wind was south-east, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
314	11.40	Sandy Hook Bay near Shrewsbury River	Lat 40 27 50 Long 74 01 25	1	Flood	20.5	16	6.23	113
315	11.50 p.m.	Sandy Hook Bay near Shrewsbury River	Lat 40 27 50 Long 74 01 25	30	Flood	20.0	16	6.28	114
316	12.20	Shrewsbury River at Spermaceti Ave.	Lat 40 24 55 Long 73 59 35	1	Flood	22.0	28	6.22	113
317	1.15	Shrewsbury River, at Highland Landing	Lat 40 23 50 Long 73 58 45	1	Flood	23.0	28	5.93	108
318	2.05	Navesink River, near mouth	Lat 40 22 50 Long 73 59 15	1	Flood	23.0	28	5.34	97
319	2.30	Shrewsbury River, opposite mouth of Navesink River	Lat 40 22 45 Long 73 58 45	1	Flood	24.0	32	5.64	106
320	3.00	Shrewsbury River, at Seabright	Lat 40 21 55 Long 73 58 40	1	Flood	25.0	32	5.64	106
321	3.45	Sandy Hook Bay, middle of bend of horse shoe	Lat 40 26 45 Long 73 59 50	1	Flood	20.5	20	6.23	113
322	4.10	Sandy Hook Bay, west of point of Sandy Hook	Lat 40 28 35 Long 74 01 25	1	Flood	20.5	20	5.93	108
323	4.20	Sandy Hook Bay, west of point of Sandy Hook	Lat 40 28 35 Long 74 01 25	40	Flood	20.0	20	5.64	103

Ex. 31. P. 34.

DARK PAGE

High water occurred at Governors Island at 5.13 p.m. The wind was south east, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	C.C. per litre	Oxygen Percent saturation
324	4.35	Lower Bay, near buoy 8 in Main Channel	Lat 40 28 45 Long 74 01 25	1	Flood	20.5	16	6.23	113
325	4.40	Lower Bay, near buoy 8 in Main Channel	Lat 40 28 45 Long 74 01 25	40	Flood	20.0	16	6.08	111
326	5.00	Lower Bay, midway between buoy 8 and Romer light	Lat 40 29 50 Long 74 01 00	1	Flood	20.5	16	6.23	113
327	5.10	Lower Bay, midway between buoy 8 and Romer light	Lat 40 29 50 Long 74 01 00	40	Flood	20.0	16	6.08	111

THE STATE OF NEW JERSEY ET AL. 3307

E BLEED THRU

Dissolved Oxygen. Lower Bay. July 14, 1909.

Low water occurred at Governors Island at 11.59 a.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
328	9.15	Just inside bell-buoy off Sea Gate Inn.	Lat 40 34 15 Long 73 59 50	1	Ebb	19.5	16	4.45	80
329	9.35	Just outside bell-buoy off Sea Gate Inn.	Lat 40 34 05 Long 73 59 50	1	Ebb	19.5	16	4.15	74
330	10.00	On East Bank	Lat 40 32 25 Long 73 59 45	1	Ebb	19.5	16	4.45	80
331	10.30	In 14 foot channel, near buoy A C 16	Lat 40 31 50 Long 74 00 25	1	Ebb	19.5	16	4.75	85
332	11.00	On Romer Shoals	Lat 40 31 20 Long 74 00 35	1	Ebb	19.5	16	4.75	85
333	11.15	In Swash Channel, 700 feet S.W. of Romer light	Lat 40 30 40 Long 74 00 50	1	Ebb	19.5	16	5.04	90
334	11.25	In Swash Channel, 700 feet S.W. of Romer light	Lat 40 30 40 Long 74 00 50	30	Ebb	19.0	16	5.17	92
335	11.55 p.m.	In Swash Channel, near junction with Main Channel	Lat 40 31 20 Long 74 02 15	1	Ebb	19.5	16	5.04	90
336	12.05	In Swash Channel, near junction with Main Channel	Lat 40 31 20 Long 74 02 15	30	Ebb	19.0	16	5.34	95
337	1.00	In Main Ship Channel, near junction with Swash Channel	Lat 40 31 20 Long 74 02 30	1	Flood	19.5	16	5.17	92
338	1.10	In Main Ship Channel, near junction with Swash Channel	Lat 40 31 20 Long 74 02 30	40	Flood	19.0	16	5.34	95
339	2.00	500 feet west of West Bank light	Lat 40 32 15 Long 74 02 45	1	Flood	19.5	16	5.04	90
340	2.50	Midway between West Bank light and Elm Tree beacon	Lat 40 33 05 Long 73 04 10	1	Flood	19.5	16	5.17	92
341	3.30	1000 feet off Elm Tree beacon	Lat 40 32 45 Long 74 05 30	1	Flood	20.0	16	4.75	86

DARK PAGE

THE PEOPLE OF THE STATE OF NEW YORK v.

Harlem River Course from Wards Island to Spuyten Duyvil. July 15, 1909.

Low water occurred at Governors Island at 12.56 p.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
342	12.30	Opposite East 109 St. midstream	Lat 40 47 23 Long 73 56 07	1	Ebb	21.0	36	1.19	21
343	12.40	Opposite East 109 St. midstream	Lat 40 47 23 Long 73 56 07	20	Ebb	21.0	36	1.21	22
344	1.05	At Third Av. bridge, midstream	Lat 40 48 25 Long 73 55 58	1	Ebb	21.0	36	1.78	32
345	1.15	At Third Av. bridge, midstream	Lat 40 48 25 Long 73 55 58	20	Ebb	21.0	36	1.82	33
346	1.25	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	1	Ebb	21.0	36	2.37	42
347	1.35	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	20	Ebb	21.0	36	2.43	43
348	1.50	At 207 St. bridge, midstream	Lat 40 51 46 Long 73 54 54	1	Ebb	21.0	36	2.67	46
349	1.55	At 207 St. bridge, midstream	Lat 40 51 46 Long 73 54 54	16	Ebb	20.0	36	2.73	47
350	2.15	200 feet east of Spuyten Duyvil drawbridge, midstream	Lat 40 52 42 Long 73 55 28	1	Ebb	21.0	36	3.26	56
351	2.20	200 feet east of Spuyten Duyvil drawbridge, midstream	Lat 40 52 42 Long 73 55 28	16	Ebb	20.0	36	3.34	58
352	3.30	200 feet east of Spuyten Duyvil drawbridge, midstream	Lat 40 52 42 Long 73 55 28	1	Flood	21.0	64	4.75	79
353	3.35	200 feet east of Spuyten Duyvil drawbridge, midstream	Lat 40 52 42 Long 73 55 28	16	Flood	21.0	64	4.41	74
354	3.45	At 207 St. bridge, midstream	Lat 40 51 46 Long 73 54 54	1	Flood	21.0	44	3.26	57
355	3.50	At 207 St. bridge, midstream	Lat 40 51 46 Long 73 54 54	16	Flood	21.0	44	3.34	59

THE STATE OF NEW JERSEY ET AL.
1907
E BLEED THRU

Dissolved Oxygen.

Harlem River Course from Wards Island to Spuyten Duyvil. (Continued.) July 15, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
356	4.10	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	1	Flood	21.5	36	2.97	53
357	4.15	At 155 St. bridge, midstream	Lat 40 49 40 Long 73 56 03	20	Flood	21.0	36	3.04	54
358	4.36	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 55 58	1	Flood	21.5	32	2.67	48
359	4.40	At Third Ave. bridge, midstream	Lat 40 48 25 Long 73 55 58	20	Flood	21.0	32	2.73	49
360	4.50	Opposite East 109 St., mid-stream	Lat 40 47 23 Long 73 56 07	1	Flood	21.0	32	2.06	37
361	4.55	Opposite East 109 St.m mid-stream	Lat 40 47 23 Long 73 56 07	20	Flood	21.0	32	2.13	38

Ex. 51. P. 38.

DARK PAGE

Low water occurred at Governors Island at 1.27 p.m. The wind was south-east, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Location of Samples: Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
362	11.30	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	1	Ebb	20.5	28	3.26	58
363	11.40	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	30	Ebb	20.0	28	3.34	59
364	11.50	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	60	Ebb	19.0	28	3.67	63
365	p.m. 1.00	Near buoy G 2, north of Robbins Reef	Lat 40 40 12 Long 74 03 10	1	Ebb	20.5	28	3.56	64
366	1.10	Near buoy G 2, North of Robbins Reef	Lat 40 40 12 Long 74 03 10	20	Ebb	20.5	28	3.67	64
367	1.20	Near buoy G 2, north of Robbins Reef	Lat 40 40 12 Long 74 03 10	50	Ebb	19.0	28	3.50	60
368	1.50	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	20.5	28	3.86	37
369	2.00	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	40	Ebb	20.0	28	3.95	70
370	2.10	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	80	Ebb	19.0	28	3.79	66
371	4.10	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Flood	20.0	20	4.45	81
372	4.20	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	40	Flood	19.5	20	4.56	81
373	4.30	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	80	Flood	19.0	20	4.37	78
374	4.45	Near buoy G 2, north of Robbins Reef	Lat 40 40 12 Long 74 03 10	1	Flood	20.0	20	4.15	76
375	4.50	Nearrbuoy G 2, north of Robbins Reef	Lat 40 40 12 Long 74 03 10	20	Flood	19.5	20	4.25	76

THE STATE OF NEW JERSEY ET AL. 1915

Dissolved Oxygen. Upper Bay and the Narrows. (Continued). July 16, 1909.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact	Feet below surface				C.C. per litre	Percent saturation
376	4.55	Near buoy G 2, north of Robbins Reef	Lat 40 40 12 Long 74 03 10	50	Flood	19.0	20	4.08	73
377	5.20	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	1	Flood	20.0	28	3.86	68
378	5.22	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	30	Flood	19.8	28	3.95	69
379	5.25	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	60	Flood	19.0	28	3.80	66

Ex. 31. P. 40.

Low water occurred at Governors Island at 2.21 p.m. The wind was east, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
380	9.30	Upper Bay, off Tompkinsville	Lat 40 38 20 Long 74 04 15	1	Ebb	21.0	28	3.98	72
381	9.40	Upper Bay, off Tompkinsville	Lat 40 38 20 Long 74 04 15	45	Ebb	20.0	28	4.18	72
382	10.10	Kill van Kull, west end	Lat 40 39 30 Long 74 08 40	1	Ebb	21.0	28	4.56	83
383	10.20	Kill van Kull, west end	Lat 40 39 30 Long 74 08 40	20	Ebb	20.0	28	4.76	86
384	10.35	Kill van Kull off Port Richmond	Lat 40 38 35 Long 74 06 00	1	Ebb	21.0	28	4.56	83
385	10.45	Kill van Kull off Port Richmond	Lat 40 38 35 Long 74 06 00	20	Ebb	20.0	28	4.48	81
386	11.00	Bodine Creek at mouth	Lat 40 38 20 Long 74 07 35	1	Ebb	22.0	28	3.86	70

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen — Upper Bay — July 17, 1909

Low water occurred at Governors Island at 2.11 p.m. The wind was east, with a velocity of 8 miles per hour.

Sample No.	Hour A.M.	Location of Samples: Approximate	Exact: o ' "	Feet below surface	Tidal current	Temp. water Deg.C.	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
387	11.25	At end of pier, foot of 68th St. Brooklyn	Lat 40 38 40 Long 74 01 55	1	Ebb	21.0	28	2.09	38
388	11.35	At end of pier, foot of 68th St. Brooklyn	Lat 40 38 40 Long 74 01 55	20	Ebb	20.0	28	2.43	44
389	11.45	By buoy off Gowanus Bay	Lat 40 39 30 Long 74 01 36	1	Ebb	21.0	28	2.09	38
390	11.50	By buoy off Gowanus Bay	Lat 40 39 30 Long 74 01 36	20	Ebb	21.0	28	2.13	39
391	12.00	Off Atlantic Docks in Buttermilk Channel	Lat 40 41 05 Long 74 00 50	1	Ebb	21.0	28	2.28	39
392	12.05	Off Atlantic Docks in Buttermilk Channel	Lat 40 41 05 Long 74 00 50	40	Ebb	20.0	28	2.34	40
393	12.15	500 feet northeast of Ellis Island	Lat 40 41 55 Long 74 02 15	1	Ebb	21.0	28	2.26	39
394	12.20	500 feet northeast of Ellis Island	Lat 40 41 55 Long 74 02 15	20	Ebb	20.0	28	2.44	41

Low water occurred at Governors Island at 4.27 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour A.M.	Location of Samples: Approximate	Lat. or Long.	Deg.	Min.	Sec.	Feet below surface	Tidal current	Temp. water deg.C.	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
395	11.45	Upper Bay, near bell buoy just south of Governors Island	Lat	40	40	56	1	Ebb	20.5	20	3.20	58
			Long	74	01	56						
396	11.50 p.m.	Upper Bay, near Bell Buoy just south of Governors Island	Lat	40	40	56	40	Ebb	19.5	20	3.34	60
			Long	74	01	56						
397	12.25	Upper Bay, 1/4 mile east of Robbins Reef light	Lat	40	39	30	1	Ebb	20.8	20	3.50	64
			Long	74	03	37						
398	12.30	Upper Bay, 1/4 mile east of Robbins Reef light	Lat	40	39	30	40	Ebb	19.0	20	3.65	65
			Long	74	03	37						
399	12.45	Narrows, midway between forts	Lat	40	36	25	1	Ebb	20.0	20	3.90	69
			Long	74	02	48						
400	12.50	Narrows, midway between forts	Lat	40	36	25	40	Ebb	19.0	20	3.98	71
			Long	74	02	48						
401	2.50	Lower Bay, 800 feet off Hortons Point	Lat	40	34	35	1	Ebb	20.0	16	4.37	80
			Long	74	00	50						
402	2.55	Lower Bay, 800 feet off Hortons Point	Lat	40	34	35	40	Ebb	19.0	16	4.56	81
			Long	74	00	50						

Dissolved Oxygen. Lower Bay. July 21, 1909.

High water occurred at Governors Island at 11.03 a.m. The wind was southeast, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate		Exact	Feet below surface	Tidal current	Temp. water Deg. F	Per-cent land water	Oxygen — C.C. per litre	Oxygen — Percentage saturation
403	7.10	Lower Bay, Point	800 feet off Hortons	Lat 40 34 35 Long 74 00 30	1	Flood	19.0	12	8.00	91
404	8.15	Lower Bay, Point	800 feet off Hortons	Lat 40 34 35 Long 74 00 30	20	Flood	19.0	12	8.08	92
408	9.15	Lower Bay,	near buoy A C 8	Lat 40 30 15 Long 73 57 40	1	Flood	19.0	8	8.88	111
406	9.30	Lower Bay,	near buoy A C 8	Lat 40 30 15 Long 73 57 40	40	Flood	19.0	8	8.16	109

Hm. 31. P. 44

Rigs were secured at Shrewsbury Inlet at 11.05 A.M. The wind was southeast, with a velocity of 8 miles per hour

Sample No.	Hour p.m.	Location of Samples — Approximate		Exact			Feet below surface	Tidal current	Temp. water Deg. C	Per-cent Salinity	Oxygen C.c. per litre	Oxygen Percent saturation
				°	'	"						
407	12.15	Ocean, 10 miles off Long Branch in Hudson gorge".	Lat	40	19	15	1	Flood	18.0	0	6.88	111
			Long	73	48	45						
408	12.30	Ocean, 10 miles off Long Branch in Hudson gorge".	Lat	40	19	18	148	Flood	14.0	0	5.98	100
			Long	73	48	45						
409	1.00	Ocean, 12 miles off Long Branch in Hudson gorge".	Lat	40	19	18	1	Flood	19.0	0	6.80	111
			Long	73	47	18						
410	1.20	Ocean, 12 miles off Long Branch in Hudson gorge".	Lat	40	19	18	180	Flood	14.9	0	5.63	99
			Long	73	47	18						
411	2.45	Ocean, at Hook	at "oil spot" off Sandy	Lat	40	27	00	1	Ebb	19.0	4	6.89	118
				Long	73	89	88						
412	2.50	Ocean, at Hook	at "oil spot" off Sandy	Lat	40	27	00	80	Ebb	19.0	4	6.89	118
				Long	73	88	80						
413	3.00	Ocean, at Hook	at "oil spot" off Sandy	Lat	40	27	00	1	Ebb	19.0	4	6.89	118
				Long	73	88	88						
414	3.05	Ocean, at Hook	at "oil spot" off Sandy	Lat	40	27	00	80	Ebb	19.0	4	6.89	118
				Long	73	88	88						
415	3.30	Ocean, at Hook	near buoy 8 off Sandy	Lat	40	28	48	1	Ebb	19.0	8	6.89	111
				Long	73	89	50						
416	3.38	Ocean, at Hook	near buoy 8 off Sandy	Lat	40	28	48	40	Ebb	18.0	8	6.09	110
				Long	73	89	50						
417	4.08	Lower Bay, near buoy A C 10		Lat	40	30	58	1	Ebb	19.0	18	6.00	109
				Long	73	98	80						
418	4.10	Lower Bay, near buoy A C 10		Lat	40	30	58	40	Ebb	18.0	18	6.98	104
				Long	73	98	80						

Dissolved Oxygen — The Narrows. July 21, 1909.

High water occurred at Governors Island at 11.03 a.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Sample — Approximate		Depth o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent chlorid water	Oxygen c.c. per litre	Oxygen Percent satura-tion
419	4.45	Narrows, midway between forts	Lat Long	40 36 25 74 02 40	1	Ebb	19.0	12	4.15	74
420	4.50	Narrows, midway between forts	Lat Long	40 36 20 74 02 40	40	Ebb	18.0	12	4.25	76

Hr. Bl. p. 46

THE PEOPLE OF THE STATE OF NEW YORK v.

High water occurred at Governors Island at 11.02 a.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples						Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen.	
		Approximate										C.C. per litre	Percent saturation
421	5.25	Upper Bay, Bush	1000 feet off Erie	Lat	40	40	20	1	Ebb	19.8	16	3.36	44
				Long	74	01	20						
422	5.30	Upper Bay, Bush	1000 feet off Erie	Lat	40	40	20	20	Ebb	18.8	16	5.44	69
				Long	74	01	20						

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. Hudson River, Upper Bay and Lower Bay.

July 22, 1909.

High water occurred at Governors Island at 11.53 a.m. The wind was south, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
423	10.20	Hudson River, midstream, off Gansevoort St.	Lat 40 44 35 Long 74 01 10	1	Flood	20.5	36	3.58	63
424	10.25	Hudson River, midstream, off Gansevoort St.	Lat 40 44 35 Long 74 01 10	60	Flood	19.0	36	3.65	63
425	10.45	Hudson River, midstream, off Desbrosses St.	Lat 40 43 30 Long 74 01 15	1	Flood	20.5	36	3.80	67
426	10.48	Hudson River, midstream, off Desbrosses St.	Lat 40 43 30 Long 74 01 15	20	Flood	20.0	36	3.86	67
427	10.52	Hudson River, midstream, off Desbrosses St.	Lat 40 43 30 Long 74 01 15	40	Flood	20.0	36	3.95	70
428	11.20	Hudson River, midstream, off Pier A	Lat 40 42 19 Long 74 01 34	1	Flood	20.5	32	3.80	68
429	11.25	Hudson River, midstream, off Pier A	Lat 40 42 19 Long 74 01 34	40	Flood	20.0	32	3.58	64
430	11.40	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	1	Flood	20.0	28	3.66	64
431	11.43	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	20	Flood	20.0	28	3.56	63
432	11.48 p.m.	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	50	Flood	19.5	28	3.50	61
433	12.10	Upper Bay, near bell-buoy G2	Lat 40 40 12 Long 74 03 10	1	Flood	20.0	28	3.80	67
434	12.13	Upper Bay, near bell buoy G2	Lat 40 40 12 Long 74 03 10	50	Flood	19.5	28	3.95	70
435	12.25	Upper Bay, near Robbins Reef bell buoy	Lat 40 39 10 Long 74 03 50	1	Flood	20.0	20	3.95	72

July 22, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
436	12.27	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	30	Flood	19.5	20	4.15	74
437	12.30	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	60	Flood	19.5	20	4.08	73
438	12.50	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Flood	20.0	16	4.45	81
439	12.55	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	90	Flood	19.0	16	4.37	78
440	1.15	Lower Bay, 500 feet off Hortons Point	Lat 40 34 36 Long 74 00 50	1	Flood	20.0	16	4.56	83

Ex. 31. p.49

THE STATE OF NEW JERSEY ET AL. vs. 3315

Dissolved Oxygen. Lower Bay, Upper Bay and Hudson River. July 22, 1909.

Low water occurred at Governors Island at 5.51 p.m. The wind was south, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C. C. per litre	Oxygen: Percent satura-tion
441	2.45	Lower Bay, 500 feet off Nortons Point	Lat 40 34 35 Long 74 00 50	1	Ebb	20.5	20	4.34	79
442	3.05	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	20.5	20	3.80	70
443	3.10	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	90	Ebb	19.0	20	3.86	70
444	3.30	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	1	Ebb	20.5	28	3.80	68
445	3.32	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	30	Ebb	20.0	28	3.95	69
446	3.37	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	60	Ebb	20.0	28	3.56	62
447	3.50	Upper Bay, near bell-buoy G 2	Lat 40 40 12 Long 74 03 10	1	Ebb	20.5	28	3.86	70
448	3.55	Upper Bay, near bell-buoy G 2	Lat 40 40 12 Long 74 03 10	50	Ebb	19.5	28	3.95	68
449	4.05	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	1	Ebb	20.5	28	3.20	57
450	4.07	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	20	Ebb	20.0	28	3.26	57
451	4.10	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 25	50	Ebb	19.5	28	3.34	59
452	4.18	Hudson River, midstream, opposite Pier A	Lat 40 42 19 Long 74 01 34	1	Ebb	20.5	32	3.20	57
453	4.21	Hudson River, midstream, opposite Pier A	Lat 40 42 19 Long 74 01 34	40	Ebb	20.0	32	3.34	59
454	4.35	Hudson River, midstream, off Debrosses St.	Lat 40 43 30 Long 74 01 15	1	Ebb	20.5	32	3.60	63
455	4.37	Hudson River, midstream, off Debrosses St.	Lat 40 43 30 Long 74 01 15	20	Ebb	20.5	32	3.58	64

July 22, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C. C. per litre	Oxygen: Percent saturation
456	4.40	Hudson River, midstream, off Desbrosses St.	Lat 40 43 30 Long 74 01 15	40	Ebb	20.0	32	3.65	64
457	4.50	Hudson River, midstream, off Gansevoort St.	Lat 40 44 35 Long 74 01 10	1	Ebb	20.5	32	3.80	68
458	4.53	Hudson River, midstream, off Gansevoort St.	Lat 40 44 35 Long 74 01 10	60	Ebb	19.5	32	3.86	68

Ex. 31. p.51

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. East River July 24, 1909

High water occurred at Governors Island at 12.53 p.m. The wind was north, with a velocity of 30 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C.	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
459	9.05	200 feet off east dock on Governors Island	Lat 40 41 35 Long 74 00 50	1	Flood	20.5	28	3.26	58
460	9.08	200 feet off east dock on Governors Island	Lat 40 41 35 Long 74 00 50	40	Flood	19.5	28	3.34	59
461	9.15	200 feet off Pier 38, Brooklyn	Lat 40 40 40 Long 74 01 15	1	Flood	20.5	28	2.97	53
462	9.18	200 feet off Pier 38, Brooklyn	Lat 40 40 40 Long 74 01 15	40	Flood	19.5	28	3.04	53
463	9.28	500 feet off Beards Erie Basin in Upper Bay	Lat 40 40 20 Long 74 01 15	1	Flood	20.5	28	3.56	62
464	9.30	500 feet off Beards Erie Basin in Upper Bay	Lat 40 40 20 Long 74 01 15	30	Flood	19.5	28	3.67	64
465	10.00	100 feet off Pier 10, Brooklyn	Lat 40 41 55 Long 73 59 55	1	Flood	20.5	28	3.26	58
466	10.05	100 feet off Pier 10, Brooklyn	Lat 40 41 55 Long 73 59 55	40	Flood	19.5	28	3.20	56
467	10.25	Foot of Oliver Street, Manhattan, Pier-head line.	Lat 40 42 30 Long 73 59 50	1	Flood	20.5	28	1.82	33
468	10.30	Foot of Oliver Street, Manhattan, Pier-head line.	Lat 40 42 30 Long 73 59 50	20	Flood	20.0	28	2.90	51
469	10.55	Foot of Corlears Street, Manhattan	Lat 40 42 35 Long 73 58 45	1	Flood	20.5	28	3.56	62
470	11.00	Foot of Corlears Street, Manhattan	Lat 40 42 35 Long 73 58 45	20	Flood	20.0	28	3.67	64

THE PEOPLE OF THE STATE OF NEW YORK V.

DARK P

High water occurred at Governors Island at 3.p.m. Ebb current ran down the river practically all day. The wind was North, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
471	11.00	500 feet off Pier 4	Lat 40 42 25 Long 74 01 10	1	Ebb	20.0	36	3.26	58
472	11.05	500 feet off Pier 4	Lat 40 42 25 Long 74 01 10	40	Ebb	19.0	36	3.34	58
473	11.20	500 feet off foot West 23 St.	Lat 40 45 09 Long 74 00 45	1	Ebb	20.0	52	3.56	61
474	11.25	500 feet off foot West 23 St.	Lat 40 45 09 Long 74 00 45	40	Ebb	19.0	52	3.65	62
475	11.40	500 feet off foot West 59 St.	Lat 40 46 28 Long 73 59 45	1	Ebb	20.0	52	3.50	60
476	11.43	500 feet off foot West 59 St.	Lat 40 46 25 Long 73 59 45	40	Ebb	19.0	52	3.56	60
477	p.m. 12.00	500 feet off foot West 96 St.	Lat 40 47 50 Long 73 58 40	1	Slack	20.0	52	3.26	56
478	12.05	500 feet off foot West 96 St.	Lat 40 47 50 Long 73 58 40	40	Slack	19.0	52	3.50	60
479	12.25	500 feet off foot West108 St.	Lat 40 48 20 Long 73 58 25	1	Slack	20.5	64	3.86	64
480	12.30	500 feet off foot West108 St.	Lat 40 48 20 Long 73 58 25	20	Slack	19.5	64	3.95	66
481	3.00	At foot of West 155 St., Washington Heights baths	Lat 40 50 00 Long 73 57 05	1	Ebb	21.0	64	4.15	69
482	3.15	At foot of West 149 St., Manhattan baths	Lat 40 49 45 Long 73 57 15	1	Ebb	21.0	64	4.08	68
483	3.25	At foot of West 136 St.	Lat 40 49 20 Long 73 57 20	1	Ebb	21.0	64	3.95	66

AGE BLEED THRU

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. Hudson River. August 19, 1909.

High water occurred at Governors Island at 10.44 a.m. The wind was south, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: Lat	°	'	"	Long	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
484	9.15	Hudson River, midstream, opposite Pier 1, Manhatten	Lat	40	42	25	Long	74	01	35	1	Flood	21.5	20	3.58	66
485	9.20	Hudson River, midstream, opposite Pier 1, Manhatten	Lat	40	42	25	Long	74	01	35	50	Flood	20.5	20	3.65	66
486	9.40	Hudson River, 1000 feet off Pier 17, Manhatten	Lat	40	43	05	Long	74	01	25	1	Flood	21.5	20	3.26	60
487	9.45	Hudson River, 1000 feet off Pier 17, Manhatten	Lat	40	43	05	Long	74	01	25	20	Flood	21.0	28	3.34	61
488	9.50	Hudson River, 1000 feet off Pier 17, Manhatten	Lat	40	43	05	Long	74	01	25	40	Flood	20.5	28	3.56	64
489	11.00	Hudson River, midstream, opposite Pier 32, Manhatten	Lat	40	43	40	Long	74	01	15	1	Flood	21.5	28	3.20	58
490	11.05	Hudson River, midstream, opposite Pier 32, Manhattan	Lat	40	43	40	Long	74	01	15	40	Flood	21.0	28	3.34	61
491	11.30	Hudson River, midstream, opposite Pier 48, Manhatten	Lat	40	44	05	Long	74	01	25	1	Flood	21.5	28	3.26	58
492	11.35	Hudson River, midstream, opposite Pier 48, Manhatten	Lat	40	44	05	Long	74	01	25	20	Flood	21.0	28	3.34	61
493	11.40	Hudson River, midstream, opposite Pier 48, Manhatten	Lat	40	44	05	Long	74	01	25	40	Flood	20.5	28	3.58	64

THE PEOPLE OF THE STATE OF NEW YORK VS.

September 7, 1909.

High water occurred at Governors Island at 2.38 p.m. The wind was southeast, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
494	10.20	800 feet off foot West 42 St.	Lat 40 45 45 Long 74 00 18	1	Ebb	21.0	52	3.76	65
495	10.25	800 feet off foot West 42 St.	Lat 40 45 45 Long 74 00 18	35	Ebb	20.5	52	3.82	66
496	10.35	800 feet off foot West 72 St.	Lat 40 46 55 Long 73 59 25	1	Ebb	21.0	52	4.05	70
497	10.37	800 feet off foot West 72 St.	Lat 40 46 55 Long 73 59 25	20	Ebb	20.5	52	4.12	71
498	11.00	800 feet off foot West 72 St.	Lat 40 46 55 Long 73 59 25	35	Ebb	20.5	52	4.21	73
499	11.35	800 feet off foot West 110 St.	Lat 40 48 20 Long 73 58 25	1	Flood	21.0	52	4.12	71
500	12.00 p.m.	800 feet off foot West 110 St.	Lat 40 48 20 Long 73 58 25	40	Flood	20.0	52	4.21	71
501	12.15	800 feet off foot West 140 St.	Lat 40 49 30 Long 73 57 30	1	Flood	21.0	52	4.23	75
502	12.17	800 feet off foot West 140 St.	Lat 40 49 30 Long 73 57 30	20	Flood	20.5	52	4.41	76
503	12.20	800 feet off foot West 140 St.	Lat 40 49 30 Long 73 57 30	40	Flood	20.0	52	4.52	77
504	12.37	800 feet off Fort Washington Point	Lat 40 51 10 Long 73 56 50	1	Flood	21.0	52	4.62	80
505	12.40	800 feet off Fort Washington Point	Lat 40 51 10 Long 73 56 50	40	Flood	20.0	52	4.82	82
506	1.00	800 feet off Inwood bathing beach	Lat 40 52 20 Long 73 55 55	1	Flood	21.0	52	4.91	85
507	1.02	800 feet off Inwood bathing beach	Lat 40 52 20 Long 73 55 55	20	Flood	20.5	52	5.00	86

THE STATE OF NEW JERSEY ET AL. vs.

Dissolved Oxygen.

Hudson River Course from 42 St. to Yonkers.

(Continued.) September 7, 1909.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Oxygen Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
508	1.08	500 feet off Inwood bathing beach	Lat 40 52 20 Long 73 56 55	40	Flood	20.0	52	5.12	87
509	1.20	500 feet off Spuyten Duyvil drawbridge	Lat 40 52 50 Long 73 55 30	1	Flood	21.0	52	4.79	83
510	1.28	500 feet off Spuyten Duyvil drawbridge	Lat 40 52 50 Long 73 55 30	40	Flood	20.0	52	4.91	83
511	1.45	500 feet off Riverdale Station	Lat 40 54 15 Long 73 56 00	1	Flood	21.0	52	5.72	99
512	1.48	500 feet off Riverdale station	Lat 40 54 15 Long 73 56 00	20	Flood	20.5	52	5.29	91
513	1.52	500 feet off Riverdale station	Lat 40 54 15 Long 73 56 00	40	Flood	20.0	52	5.20	88
514	2.15	500 feet off Federal refinery, Yonkers	Lat 40 55 50 Long 73 54 30	1	Flood	21.0	52	4.91	85
515	2.18	500 feet off Federal refinery, Yonkers	Lat 40 55 50 Long 73 54 30	40	Flood	20.0	52	5.12	87
516	2.40	500 feet off Power Plant, northern end of Yonkers	Lat 40 57 00 Long 73 54 10	1	Flood	21.0	52	5.20	90
517	2.43	500 feet off power plant, northern end of Yonkers	Lat 40 57 00 Long 73 54 10	20	Flood	21.0	52	5.29	91
518	2.46	500 feet off power plant, northern end of Yonkers	Lat 40 57 00 Long 73 54 10	35	Flood	20.5	52	5.42	94

Ex. 31. p.86

THE PEOPLE OF THE STATE OF NEW YORK vs.

September 8, 1909

High water occurred at Governors Island at 3.28 p.m. The wind was south-east, with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent ature-tion
819	1.30	Passaic River, near foot of N. J. R. R. Avenue, Newark	Lat 40 44 49 Long 74 09 58	1	Flood	22.0	52	0	0
820	1.32	Passaic River, near foot of N. J. R. R. Avenue, Newark	Lat 40 44 49 Long 74 09 58	10	Flood	21.5	52	0	0
821	2.17	Passaic River, 100 feet above P. R. R. freight bridge	Lat 40 44 10 Long 74 09 48	1	Flood	21.5	40	2.02	36
822	2.20	Passaic River, 100 feet above P. R. R. freight bridge	Lat 40 44 10 Long 74 09 45	10	Flood	21.0	40	2.06	36
823	2.40	Passaic River, near mouth	Lat 40 43 15 Long 74 07 20	1	Flood	21.0	40	2.89	51
824	2.43	Passaic River, near mouth	Lat 40 43 15 Long 74 07 20	10	Flood	20.5	40	2.94	52
825	3.00	Newark Bay, near Lehigh Valley R. R. bridge	Lat 40 41 56 Long 74 07 15	1	Flood	21.0	28	4.08	74
826	3.02	Newark Bay, near Lehigh Valley R.R. bridge	Lat 40 41 56 Long 74 07 15	10	Flood	20.5	28	4.12	74
827	3.23	Newark Bay, near bell-buoy off Centreville	Lat 40 40 15 Long 74 08 10	1	Flood	21.0	28	3.76	68
828.	3.25	Newark Bay, near bell-buoy off Centreville	Lat 40 40 15 Long 74 08 10	10	Flood	20.5	28	4.12	72
829	3.40	Newark Bay, near C. R. R. of N. J. drawbridge	Lat 40 39 17 Long 74 08 46	1	Flood	20.5	28	3.76	67
830	3.42	Newark Bay, near C. R. R. of N. J. drawbridge	Lat 40 39 17 Long 74 08 46	15	Flood	20.5	28	3.82	67
831	3.45	Newark Bay, near C. R. R. of N. J. drawbridge	Lat 40 39 17 Long 74 08 46	30	Flood	20.0	28	3.91	69

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. Passaic River, Newark Bay and Kill van Kull.

(Continued.) September 8, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen — C.C. per litre	Oxygen — Percent saturation
532	4.00	Kill van Kull, west end	Lat 40 39 35 Long 74 08 46	1	Flood	20.0	20	3.47	63
533	4.03	Kill van Kull, west end	Lat 40 39 46 Long 74 08 45	35	Flood	20.0	20	3.61	66
534	4.25	Kill van Kull, opposite Sailors Snug Harbor	Lat 40 39 40 Long 74 06 25	1	Flood	19.5	20	3.76	67
535	4.27	Kill van Kull, opposite Sailors Snug Harbor	Lat 40 39 30 Long 74 06 22	20	Flood	19.0	20	3.96	66
536	4.30	Kill van Kull, opposite Sailors Snug Harbor	Lat 40 39 30 Long 74 06 22	40	Flood	19.0	20	4.21	75
537	4.40	Kill van Kull, opposite Constable Hook	Lat 40 39 05 Long 74 05 17	1	Flood	20.0	20	4.11	73
538	4.42	Kill van Kull, opposite Constable Hook	Lat 40 39 05 Long 74 05 15	40	Flood	19.0	20	4.52	81

September 9, 1909.

Low water occurred at Governors Island at 10.40 a.m. The wind was southeast, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate to	Latitude	Longitude	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
539	11.10	East River, midstream, off Battery	Lat 40 41 30	Long 74 00 58	1	Ebb	20.0	32	5.18	84
540	11.14	East River, midstream, off Battery	Lat 40 41 30	Long 74 00 58	20	Ebb	19.5	32	5.24	87
541	11.18	East River, midstream, off Battery	Lat 40 41 30	Long 74 00 58	40	Ebb	19.0	32	5.91	98
542	11.32	East River, midstream, at Brooklyn bridge	Lat 40 42 30	Long 73 59 48	1	Ebb	20.0	32	5.18	86
543	11.36	East River, midstream, at Brooklyn bridge	Lat 40 42 30	Long 73 59 48	40	Ebb	19.0	32	5.53	91
544	11.54	East River, midstream, at Williamsburg bridge	Lat 40 42 09	Long 73 58 23	1	Ebb	20.0	32	5.47	91
545	11.57	East River, midstream, at Williamsburg Bridge	Lat 40 42 09	Long 73 58 23	20	Ebb	19.5	32	5.53	92
546	12.00 p.m.	East River, midstream, at Williamsburg bridge	Lat 40 42 09	Long 73 58 23	40	Ebb	19.0	32	5.61	92
547	12.14	East River, midstream, off East 23 St.	Lat 40 44 00	Long 73 58 08	1	Ebb	20.0	32	5.24	87
548	12.17	East River, midstream, off East 23 St.	Lat 40 44 00	Long 73 58 08	20	Ebb	19.0	32	5.61	92
549	12.25	East River, east channel off East 49 St.	Lat 40 45 00	Long 73 57 30	1	Ebb	20.0	32	5.47	91
550	12.27	East River, east channel off East 49 St.	Lat 40 45 00	Long 73 57 30	20	Ebb	19.0	32	5.82	96
551	12.30	East River, east channel off East 49 St.	Lat 40 45 00	Long 73 57 30	40	Ebb	19.0	32	5.91	97

Ex. 31. p.89

Dissolved Oxygen. East River Course from Battery to Clason Point.

(Continued). September 9, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
				'	"						
552	12.42	East River, east channel, off East 70 St.	Lat 40	45	45	1	Flood	20.0	32	3.47	61
			Long 73	56	30						
553	12.45	East River, east channel, off East 70 St.	Lat 40	45	45	20	Flood	19.0	32	3.53	61
			Long 73	56	30						
554	12.58	East River, at Hell Gate	Lat 40	46	30	1	Flood	20.0	32	3.61	63
			Long 73	56	00						
555	12.57	East River, at Hell Gate	Lat 40	46	30	20	Flood	19.5	32	3.82	67
			Long 73	56	00						
556	1.00	East River, at Hell Gate	Lat 40	46	30	40	Flood	19.0	32	3.91	67
			Long 73	56	00						
557	1.22	East River, between North and South Brother Islands	Lat 40	47	55	1	Flood	19.5	33	4.08	71
			Long 73	53	55						
558	1.25	East River, between North and South Brother Islands	Lat 40	47	55	40	Flood	19.0	33	4.32	70
			Long 73	53	55						
559	1.50	East River, midstream, off Clason Point	Lat 40	48	00	1	Flood	19.0	33	4.33	70
			Long 73	50	40						
560	1.55	East River, midstream, off Clason Point	Lat 40	48	00	30	Flood	19.0	33	4.32	70
			Long 73	50	40						
561	2.00	East River, midstream, off Clason Point	Lat 40	48	00	70	Flood	18.8	33	4.41	70
			Long 73	50	40						

Ex. 31. p.80

Low water occurred at Governors Island at 10.40 a.m. The wind was southwest, with a velocity of 8 miles per hour. The current was flowing eastward.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen — C.C. per litre	Oxygen — Percent saturation
562	2.30	Long Island Sound, 800 feet east of Throgs Neck	Lat 40 48 20 Long 73 47 20	1	Flood	19.0	28	5.49	95
563	2.35	Long Island Sound, 800 feet east of Throgs Neck	Lat 40 48 20 Long 73 47 20	40	Flood	18.5	29	5.72	97
564	2.55	Long Island Sound, near Stepping Stones light	Lat 40 49 30 Long 73 46 30	1	Flood	19.0	29	5.80	100
565	2.57	Long Island Sound, near Stepping Stones light	Lat 40 49 30 Long 73 46 30	20	Flood	18.5	29	5.88	100
566	3.00	Long Island Sound, near Stepping Stones light	Lat 40 49 30 Long 73 46 30	40	Flood	18.5	29	6.02	102

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. East River Course from Hell Gate to Battery.

September 10, 1909.

Low water occurred at Governors Island at 11.27 a.m. The wind was southeast, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
567	9.55	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 30	1	Ebb	19.5	32	4.05	71
568	9.57	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 30	40	Ebb	19.0	32	4.21	74
569	10.10	West Channel, off East 59 St.	Lat 40 45 25 Long 73 57 30	1	Ebb	19.5	32	3.76	68
570	10.12	West Channel, off East 59 St.	Lat 40 45 25 Long 73 57 30	20	Ebb	19.0	32	3.82	67
571	10.15	West Channel, off East 59 St.	Lat 40 45 25 Long 73 57 30	40	Ebb	19.0	32	3.91	69
572	10.25	Off East 34 St., midstream	Lat 40 44 25 Long 73 58 00	1	Ebb	19.5	32	3.76	66
573	10.28	Off East 34 St., midstream	Lat 40 44 25 Long 73 58 00	40	Ebb	19.0	32	3.61	63
574	10.35	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	1	Ebb	19.5	32	3.53	62
575	10.37	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	20	Ebb	19.0	32	3.76	66
576	10.40	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	40	Ebb	19.0	32	3.91	69
577	10.47	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	1	Ebb	19.5	32	3.47	61
578	10.50	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	40	Ebb	19.0	32	3.61	63
579	10.55	Off Battery, Midstream	Lat 40 41 50 Long 74 00 50	1	Ebb	19.5	32	3.47	61
580	10.57	Off Battery, midstream	Lat 40 41 50 Long 74 00 50	20	Ebb	19.0	32	3.82	67
581	11.00	Off Battery, midstream	Lat 40 41 50 Long 74 00 50	40	Ebb	19.0	32	3.91	69

Ex. 81. p.68

THE PEOPLE OF THE STATE OF NEW YORK VS.

8882

Dissolved Oxygen. Kill von Kull. September 11, 1909.

Dissolved Oxygen. Kill van Kull. September 11, 1909.

Low water occurred at Governors Island at 12.27 p.m. The wind was northwest, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
582	9.40	Upper Bay, 500 feet off St. George ferry	Lat 40 38 55 Long 74 04 50	1	Ebb	19.5	28	4.91	87
583	9.43	Upper Bay, 500 feet off St. George ferry	Lat 40 38 55 Long 74 04 50	40	Ebb	19.0	28	5.12	88
584	10.06	Kill van Kull, midstream, off New Brighton station	Lat 40 38 57 Long 74 06 25	1	Ebb	19.5	28	4.33	76
585	10.08	Kill van Kull, midstream, off New Brighton station	Lat 40 38 57 Long 74 06 25	20	Ebb	19.0	28	4.41	76
586	10.10	Kill van Kull, midstream, off New Brighton station	Lat 40 38 57 Long 74 06 25	40	Ebb	19.0	28	4.52	78
587	10.25	Kill van Kull, midstream, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 07	1	Ebb	19.5	28	3.76	66
588	10.28	Kill van Kull, midstream, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 07	40	Ebb	19.0	28	4.21	73
589	10.45	Kill van Kull, midstream, off Port Richmond ferry	Lat 40 38 35 Long 74 07 52	1	Ebb	19.5	28	4.05	71
590	10.47	Kill van Kull, midstream, off Port Richmond ferry	Lat 40 38 35 Long 74 07 52	20	Ebb	19.0	28	4.41	76
591	10.50	Kill van Kull, midstream, off Port Richmond ferry	Lat 40 38 35 Long 74 07 52	30	Ebb	19.0	28	4.52	78
592	11.10	Kill van Kull, west end,	Lat 40 28 35 Long 74 09 30	1	Ebb	19.5	28	4.05	71
593	11.12	Kill van Kull, west end,	Lat 40 28 35 Long 74 09 30	30	Ebb	19.0	28	4.21	73

Dissolved Oxygen. Lower Bay. September 13, 1909.

Low water occurred at Governors Island at 1.55 p.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
594	11.00	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 35	1	Ebb	19.5	16	4.34	78
595	11.05	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 35	20	Ebb	19.0	16	5.59	100
596	11.10	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 35	35	Ebb	18.5	16	5.72	102
597	11.30	In Fourteen Foot Channel, near buoy A C 20	Lat 40 32 25 Long 74 00 45	1	Ebb	19.5	16	4.62	83
598	11.35 p.m.	In Fourteen Foot Channel, near buoy A C 20	Lat 40 32 25 Long 74 00 45	25	Ebb	18.5	16	5.72	102
599	12.35	Between Ambrose and Fourteen Foot Channels, near buoy A C 10	Lat 40 31 00 Long 73 58 45	1	Ebb	19.5	16	4.62	83
600	12.40	Between Ambrose and Fourteen Foot Channels, near buoy A C 10	Lat 40 31 00 Long 73 58 45	20	Ebb	19.0	16	5.72	102
601	1.05	About 1000 feet north of buoy A C 4	Lat 40 30 20 Long 73 57 00	1	Ebb	20.0	16	5.49	100
602	1.10	About 1000 feet north of buoy A C 4	Lat 40 30 20 Long 73 57 00	20	Ebb	19.5	16	6.19	110
603	1.20	Near Ambrose Channel buoy 4	Lat 40 30 10 Long 73 56 55	1	Ebb	20.0	16	5.79	105
604	1.25	Near Ambrose Channel buoy 4	Lat 40 30 10 Long 73 56 55	35	Ebb	19.5	16	6.17	110
605	1.35	Near Ambrose Channel buoy 3	Lat 40 29 55 Long 73 57 05	1	Ebb	20.0	16	5.49	100
606	1.37	Near Ambrose Channel buoy 3	Lat 40 29 55 Long 73 57 05	20	Ebb	19.5	16	5.89	105
607	1.47	100 feet north of Gedney Channel buoy 6	Lat 40 29 30 Long 73 57 20	1	Ebb	20.0	16	5.79	105

THE STATE OF NEW YORK

Dissolved Oxygen. Lower Bay. (Continued). September 13, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
608	1.50	100 feet north of Gedney Channel buoy 6	Lat 40 29 39 Long 73 57 20	30	Flood	19.0	16	5.89	105
609	2.10	Between Gedney Channel buoys 6 and 5	Lat 40 29 25 Long 73 57 20	1	Flood	19.5	16	5.79	103
610	2.15	Between Gedney Channel buoys 6 and 5	Lat 40 29 25 Long 73 57 20	35	Flood	18.5	16	6.02	108
611	2.25	200 feet south of Gedney Channel buoy 5	Lat 40 29 10 Long 73 57 20	1	Flood	19.5	16	5.79	103
612	2.28	200 feet south of Gedney Channel buoy 5	Lat 40 29 10 Long 73 57 20	28	Flood	19.0	16	5.89	105
613	2.40	100 feet south of buoy C B 1 off Sandy Hook	Lat 40 29 15 Long 73 58 15	1	Flood	19.5	16	6.07	109
614	2.43	100 feet south of buoy C B 1 off Sandy Hook	Lat 40 29 15 Long 73 58 15	30	Flood	19.0	16	6.19	110
615	2.55	500 feet southeast of buoy C B 3 off Sandy Hook	Lat 40 28 50 Long 73 59 10	1	Flood	19.5	16	6.07	109
616	3.00	500 feet southeast of buoy C B 3 off Sandy Hook	Lat 40 28 50 Long 73 59 10	35	Flood	19.0	16	6.19	110
617	3.30	1000 feet northeast of buoy N 8	Lat 40 28 55 Long 74 01 20	1	Flood	19.5	16	5.49	98
618	3.35	1000 feet northeast of buoy N 8	Lat 40 28 55 Long 74 01 20	15	Flood	18.5	16	5.89	105
619	3.55	500 feet southwest buoy C S 1, near Swash Channel	Lat 40 29 35 Long 74 00 30	1	Flood	19.5	16	5.59	100
620	4.00	500 feet southwest buoy C S 1. near Swash Channel	Lat 40 29 35 Long 74 00 30	35	Flood	18.5	16	6.02	108

Dissolved Oxygen. Lower Bay. September 14, 1909.

Low water occurred at Governors Island at 2.40 p.m. The wind was southeast, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
621	10.30	Main Ship Channel, 200 feet east of West Bank light	Lat 40 32 20 Long 74 02 30	1	Ebb	19.5	16	4.91	88
622	10.35	Main Ship Channel, 200 feet east of West Bank light	Lat 40 32 20 Long 74 02 30	35	Ebb	18.5	16	5.29	94
623	10.55	Swash Channel, near Main Ship Channel	Lat 40 31 25 Long 74 02 20	1	Ebb	19.5	16	4.91	88
624	11.00	Swash Channel, near Main Ship Channel	Lat 40 31 25 Long 74 02 20	30	Ebb	19.0	16	5.29	94
625	11.25	Swash Channel, 300 feet northeast of buoy C S 3	Lat 40 30 50 Long 74 01 45	1	Ebb	19.5	16	5.20	93
626	11.30	Swash Channel, 300 feet northeast of buoy C S 3	Lat 40 30 50 Long 74 01 45	20	Ebb	19.0	16	5.59	100
627	11.47	Swash Channel, 500 feet south of Romer Shoals light	Lat 40 30 45 Long 74 00 45	1	Ebb	19.5	16	4.91	88
628	11.50	Swash Channel, 500 feet south of Romer Shoals light	Lat 40 30 45 Long 74 00 45	20	Ebb	19.0	16	5.00	89
629	1.00	Swash Channel, 500 feet south of buoy N S 4	Lat 40 30 00 Long 73 59 45	1	Ebb	19.5	16	5.49	98
630	1.05	Swash Channel, 500 feet south of buoy N S 4	Lat 40 30 00 Long 73 59 45	30	Ebb	19.0	16	5.59	100
631	1.20	Swash Channel, 500 feet north of buoy C S 1	Lat 40 29 45 Long 74 00 30	1	Ebb	19.5	16	5.20	93
632	1.25	Swash Channel, 500 feet north of buoy C S 1	Lat 40 29 45 Long 74 00 30	25	Ebb	19.0	16	5.29	94
633	1.45	Romer Shoals, 500 feet northwest of buoy N S 2	Lat 40 29 50 Long 73 59 20	1	Ebb	19.5	16	5.29	94
634	1.50	Romer Shoals, 500 feet northwest of buoy N S 2	Lat 40 29 50 Long 73 59 20	25	Ebb	19.0	16	5.42	97

THE PEOPLE OF THE STATE OF NEW YORK v.

Sample No.	Hour p.m.	Location of Samples — Approximate		Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percentage saturation
635	2.05	500 feet southeast of buoy A C 9, Ambrose Channel	Lat	40	30	45	1	Ebb	19.5	16	5.20	93
			Long	73	58	45						
636	2.10	500 feet southeast of buoy A C 9, Ambrose Channel	Lat	40	30	45	20	Ebb	19.0	16	5.29	94
			Long	73	58	45						
637	2.15	500 feet northwest of buoy A C 10, Ambrose Channel	Lat	40	31	00	1	Ebb	19.5	16	5.00	89
			Long	73	56	55						
638	2.20	500 feet northwest of buoy A C 10, Ambrose Channel	Lat	40	31	00	28	Ebb	19.0	16	5.12	92
			Long	73	56	55						
639	2.45	One third of distance between buoy A C 8 and Manhattan Beach	Lat	40	32	05	1	Ebb	19.5	16	5.12	92
			Long	73	57	40						
640	2.50	One third of distance between buoy A C 8 and Manhattan Beach	Lat	40	32	05	20	Ebb	19.0	16	5.29	94
			Long	73	57	40						
641	3.10	Two thirds of distance between buoy A C 8 and Manhattan Beach	Lat	40	33	06	1	Ebb	19.5	16	4.91	88
			Long	73	57	25						
642	3.15	Two thirds of distance between buoy A C 8 Manhattan Beach	Lat	40	33	05	22	Ebb	19.0	16	5.12	92
			Long	73	57	25						

THE STATE OF NEW JERSEY ET AL.

Dissolved Oxygen. Passaic River, Newark Bay, and Kill van Kull.

September 15, 1909.

Low water occurred at Governors Island at 2.55 p.m. The wind was southeast, with a velocity of 20 miles per hour.

Sample No.	Hour p.m.	Location of Sample: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
643	12.40	Passaic River, near foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 58	1	Ebb	22.0	52	0	0
644	12.45	Passaic River, near foot of N. J. R. R. Ave., Newark	Lat 40 44 49 Long 74 09 58	10	Ebb	21.5	52	0	0
645	1.05	Passaic River, near P. R. R. freight bridge, below Newark	Lat 40 44 10 Long 74 09 45	1	Ebb	22.0	51	1.46	20
646	10.8	Passaic River, near P. R. R. freight bridge, below Newark	Lat 40 44 10 Long 74 09 45	10	Ebb	21.5	52	1.18	20
647	1.25	Passaic River, near mouth	Lat 40 43 16 Long 74 07 20	1	Ebb	21.0	52	2.60	45
648	1.30	Passaic River, near mouth	Lat 40 43 16 Long 74 07 20	10	Ebb	20.5	52	2.72	47
649	1.45	Newark Bay, near Lehigh Valley R. R. bridge	Lat 40 41 56 Long 74 07 15	1	Ebb	20.0	52	3.76	66
650	1.50	Newark Bay, near Lehigh Valley R. R. bridge	Lat 40 41 56 Long 74 07 15	20	Ebb	19.5	52	3.91	69
651	2.08	Newark Bay, near bell-buoy off Centreville	Lat 40 40 15 Long 74 08 10	1	Ebb	20.0	52	4.04	71
652	2.08	Newark Bay, near bell-buoy off Centreville	Lat 40 40 15 Long 74 08 10	20	Ebb	20.0	52	4.22	74
653	2.15	Newark Bay, near C. R. R. of N. J. drawbridge	Lat 40 39 17 Long 74 08 46	1	Ebb	20.0	52	4.04	71
654	2.18	Newark Bay, near C. R. R. of N. J. drawbridge	Lat 40 39 17 Long 74 08 46	20	Ebb	19.0	52	4.22	73
655	2.25	Kill van Kull, West end	Lat 40 38 48 Long 74 08 45	1	Ebb	20.0	28	4.34	76
656	2.27	Kill van Kull, West End	Lat 40 38 45 Long 74 08 48	20	Ebb	19.5	28	4.41	93

THE PEOPLE OF THE STATE OF NEW YORK vs

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
657	2.20	Kill van Kull, west end	Lat 40 38 35 Long 74 08 48	35	Sbb	19.0	29	4.52	78
658	2.43	Kill van Kull, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 28	1	Sbb	20.0	32	4.04	71
659	2.45	Kill van Kull, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 28	30	Sbb	19.5	28	4.22	74
660	2.55	Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 08 15	1	Sbb	20.0	26	4.34	76
661	2.57	Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 08 15	20	Sbb	19.5	28	4.41	78
662	3.00	Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 08 15	40	Sbb	19.0	26	4.82	82

THE STATE OF NEW JERSEY ET AL.
vs.
ERIE

Dissolved Oxygen. Arthur Kills. September 16, 1910.

Low water occurred at Governors Island at 3.27 p.M. The wind was southeast, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
668	11.88	Rahway River, 1/2 mile from mouth	Lat 40 36 56 Long 74 12 46	1	Ebb	20.0	64	3.49	80
664	11.57 p.M.	Rahway River, 1/2 mile from mouth	Lat 40 36 56 Long 74 12 46	8	Ebb	19.8	64	3.61	80
665	12.28	Arthur Kills, opposite mouth of Rahway River	Lat 40 36 36 Long 74 12 15	1	Ebb	20.0	89	3.76	86
666	12.30	Arthur Kills, opposite mouth of Rahway River	Lat 40 36 36 Long 74 12 15	10	Ebb	19.8	89	3.92	89
667	1.06	Arthur Kills, off Fresh Kills	Lat 40 34 46 Long 74 12 36	1	Ebb	20.0	89	4.04	91
668	1.10	Arthur Kills, off Fresh Kills	Lat 40 34 46 Long 74 12 36	16	Ebb	19.8	89	4.34	96
669	1.20	Arthur Kills, near buoy S A off Smoking Point	Lat 40 33 30 Long 74 13 40	1	Ebb	19.0	89	4.06	90
670	1.28	Arthur Kills, near buoy S A off Smoking Point	Lat 40 33 30 Long 74 13 40	28	Ebb	19.8	25	4.82	77
671	2.00	Arthur Kills, near buoy S 6, north of Rahway River	Lat 40 36 46 Long 74 12 06	1	Ebb	19.8	28	4.41	78
672	2.08	Arthur Kills, near buoy S 6, north of Rahway River	Lat 40 36 46 Long 74 12 06	12	Ebb	19.8	89	4.81	79
673	2.35	Arthur Kills, 1000 feet west of Elizabethport drawbridge	Lat 40 39 10 Long 74 11 56	1	Ebb	19.8	89	3.47	80
674	2.39	Arthur Kills, 1000 feet west of Elizabethport drawbridge	Lat 40 39 10 Long 74 11 56	12	Ebb	19.0	28	4.22	75
675	2.50	Arthur Kills, 1000 feet east of Elizabethport drawbridge	Lat 40 39 20 Long 74 11 46	1	Ebb	19.8	89	3.76	86
676	2.55	Arthur Kills, 1000 feet east of Elizabethport drawbridge	Lat 40 39 20 Long 74 11 46	16	Ebb	19.0	28	4.24	78

Sa. Bl. p.70

THE PEOPLE OF THE STATE OF NEW YORK v.

Sample No.	Hour p.m.	Location of Sampler: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
677	3.08	Arthur Kills, near buoy S 4, at east end	Lat 40 38 48 Long 74 10 48	1	Ebb	19.8	89	4.41	79
678	3.07	Arthur Kills, near buoy S 4, at East end	Lat 40 38 48 Long 74 10 48	16	Ebb	19.0	89	4.82	79
679	3.17	Midway between Shooters Island and Mariners Harbor	Lat 40 38 38 Long 74 09 30	1	Ebb	19.8	89	4.41	79
680	3.20	Midway between Shooters Island and Mariners Harbor	Lat 40 38 38 Long 74 09 30	70	Ebb	19.0	89	4.82	79
681	3.36	Kill van Kull, west end	Lat 40 38 38 Long 74 08 48	1	Ebb	19.8	89	4.84	79
682	3.40	Kill van Kull, west end	Lat 40 38 38 Long 74 08 48	38	Ebb	19.0	89	4.82	79

THE STATE OF NEW JERSEY ET AL. 11111

Dissolved Oxygen. Jamaica Bay. September 17, 1909.

Low water occurred at Governors Island at 4.47 p.m. The wind was northwest, with a velocity of 9 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen — C.C. per litre	Oxygen — Percent saturation
683	10.40	Jamaica Bay, near Dead Horse Creek	Lat 40 34 26 Long 73 84 23	1	Ebb	19.5	20	4.34	79
684	10.48	Jamaica Bay, near Dead Horse Creek	Lat 40 34 28 Long 73 84 08	18	Ebb	19.6	20	4.68	85
685	11.00	Jamaica Bay, 800 feet off Barren Island	Lat 40 34 40 Long 73 83 00	1	Ebb	19.5	20	4.34	79
686	11.08	Jamaica Bay, 200 feet off Barren Island	Lat 40 34 42 Long 73 83 00	10	Ebb	19.0	20	4.82	81
687	11.28	Just south of Ruffle Bar	Lat 40 33 40 Long 73 81 28	1	Ebb	19.0	20	1.52	68
688	11.30	Just south of Ruffle Bar	Lat 40 33 40 Long 73 81 30	11	Ebb	19.0	20	5.10	94
689	11.50	About 1 mile off Canarsie breakwater	Lat 40 34 48 Long 73 82 28	1	Ebb	19.5	20	4.04	78
690	11.55	About 1 mile off Canarsie breakwater	Lat 40 34 45 Long 73 82 28	9	Ebb	19.0	20	4.82	91
691	12.10	800 feet off Canarsie light	Lat 40 37 50 Long 73 80 48	1	Ebb	19.5	20	3.76	67
692	12.12	800 feet off Canarsie light	Lat 40 37 50 Long 73 80 48	16	Ebb	19.5	20	3.91	70
693	1.00	200 feet off Canarsie landing	Lat 40 37 40 Long 73 80 10	1	Ebb	19.5	20	3.47	62
694	1.08	200 feet off Canarsie landing	Lat 40 37 40 Long 73 80 10	8	Ebb	19.5	20	3.81	68
695	2.00	1000 feet off mouth of Fresh Creek	Lat 40 38 50 Long 73 87 18	1	Ebb	19.5	20	1.44	26
696	2.18	1000 feet off mouth of Fresh Creek	Lat 40 38 50 Long 73 87 18	1	Ebb	19.5	20	0.59	11

(Cont. on p. 72)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tide current	Temp. water Deg. C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
697	2.30	1/2 mile north of mouth of Seaman Creek	Lat	40	38	45	1	Ebb	19.5	20	4.91	68
			Long	73	51	50						
698	3.00	1000 feet off shore of Sand Bay	Lat	40	36	09	1	Ebb	19.8	20	3.18	57
			Long	73	52	40						

Dissolved Oxygen. Hudson River. September 18, 1909.

High water occurred at Governors Island at 10.36 a.m. The wind was south-west, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
699	10.05	500 feet off C. R. R. of N. J. ferry, Communipaw	Lat 40 42 25 Long 74 02 00	1	Flood	19.5	28	4.34	76
700	10.08	500 feet off C. R. R. of N. J. ferry Communipaw	Lat 40 42 25 Long 74 02 00	40	Flood	18.5	28	4.52	77
701	10.15	500 feet off P. R. R. ferry Jersey City	Lat 40 43 00 Long 74 01 55	1	Flood	19.5	28	4.04	71
702	10.17	500 feet off P. R. R. ferry Jersey City	Lat 40 43 00 Long 74 01 55	20	Flood	19.0	28	4.12	71
703	10.19	500 feet off P. R. R. ferry Jersey City	Lat 40 43 00 Long 74 01 55	40	Flood	18.5	28	4.22	72
704	10.35	500 feet off Lackawanna ferry, Hoboken	Lat 40 43 40 Long 74 01 50	1	Flood	19.5	28	3.76	66
705	10.38	500 feet off Lackawana ferry, Hoboken	Lat 40 43 40 Long 74 01 50	40	Flood	18.5	28	3.91	66
706	10.50	500 feet off Stevens Point Hoboken	Lat 40 44 40 Long 74 01 20	1	Flood	19.5	28	4.04	71
707	10.52	500 feet off Stevens Point Hoboken	Lat 40 44 40 Long 74 01 20	20	Flood	19.0	28	4.22	73
708	10.55	500 feet off Stevens Point Hoboken	Lat 40 44 40 Long 74 01 20	40	Flood	18.5	28	4.41	75
709	11.25	500 feet off West Shore ferry, Weehawken	Lat 40 46 45 Long 74 00 20	1	Flood	19.5	28	4.12	72
710	11.28	500 feet off West Shore ferry, Weehawken	Lat 40 46 45 Long 74 00 20	40	Flood	18.5	28	4.34	74

Ex. 31. p.74

THE PEOPLE OF THE STATE OF NEW YORK VS.

Low water occurred at Governors Island at 8.27 p.M. The wind was southeast, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
711	11.55	500 feet southwest of West Bank light	Lat 40 32 10 Long 74 02 40	1	Flood	19.0	8	5.20	95
712	11.58	500 feet southwest of West Bank light	Lat 40 32 10 Long 74 02 40	20	Flood	18.5	8	5.72	102
713	12.20 p.m.	About 1 mile from West Bank light, on line with Port Monmouth	Lat 40 31 25 Long 74 03 00	1	Flood	19.0	8	5.20	95
714	12.22	About 1 mile from West Bank light, on line with Port Monmouth	Lat 40 31 25 Long 74 03 00	20	Flood	18.5	8	5.72	102
715	1.00	Near white buoy S on same line	Lat 40 30 20 Long 73 03 15	1	Flood	19.0	8	5.20	95
716	1.05	Near white buoy S on same line	Lat 40 30 20 Long 73 03 15	20	Flood	18.5	8	5.42	97
717	1.20	Farther south on same line	Lat 40 29 25 Long 74 03 25	1	Flood	19.0	8	5.00	91
718	1.25	Farther south on same line	Lat 40 29 35 Long 74 03 25	25	Flood	18.5	8	5.42	97
719	1.40	Farther south on same line near buoy C C 1	Lat 40 28 35 Long 74 03 15	1	Flood	19.0	8	5.20	95
720	1.43	Farther south on same line near buoy C. C 1	Lat 40 28 35 Long 74 03 15	25	Flood	18.5	8	5.42	97
721	2.00	Farther south on same line	Lat 40 27 40 Long 74 02 40	1	Flood	19.0	8	4.91	90
722	2.03	Farther south on same line	Lat 40 27 40 Long 74 02 40	20	Flood	18.5	8	5.12	92
723	2.20	About 1 mile off Atlantic Highlands	Lat 40 26 25 Long 74 03 15	1	Flood	18.5	8	4.91	88

Sr. 31. p.75

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
724	2.23	About 1 mile off Atlantic Highlands	Lat 40 26 25 Long 74 03 15	20	Flood	18.5	8	5.12	92
725	2.40	About 1/2 mile off Atlantic Highlands	Lat 40 25 50 Long 74 03 25	1	Ebb	19.0	8	4.91	90
726	2.43	About 1/2 mile off Atlantic Highlands	Lat 40 25 50 Long 74 03 25	18	Ebb	18.5	8	5.00	89
727	3.40	2000 feet west of buoy S 1 W. off Point Comfort	Lat 40 29 00 Long 74 07 50	1	Ebb	19.0	8	5.79	104
728	3.42	2000 feet west of buoy S 1 W. off Point Comfort	Lat 40 29 00 Long 74 07 50	12	Ebb	18.5	8	6.20	110
729	4.00	Nearer Great Kills	Lat 40 29 50 Long 74 07 40	1	Ebb	19.0	8	6.07	109
730	4.02	Nearer Great Kills	Lat 40 29 50 Long 74 07 40	25	Ebb	18.5	8	6.02	108
731	4.20	1 1/2 miles south of Great Kills	Lat 40 30 35 Long 74 07 40	1	Ebb	19.0	8	5.79	104
732	4.23	1 1/2 miles south of Great Kills	Lat 40 30 35 Long 74 07 40	15	Ebb	18.5	8	6.02	108
733	4.32	1 mile south of Great Kills	Lat 40 31 10 Long 74 07 45	1	Ebb	19.0	8	5.79	104
734	4.35	1 mile south of Great Kills	Lat 40 31 10 Long 74 07 45	10	Ebb	18.5	8	6.02	108

THE PEOPLE OF THE STATE OF NEW YORK vs.

Low water occurred at Governors Island at 6.52 p.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
735	11.45	Raritan Bay, 1000 feet east of buoy S 2, off Seguine Point	Lat 40 30 30 Long 74 01 05	1	Flood	19.0	8	6.07	110
736	11.47 p.m.	Raritan Bay, 1000 feet east of buoy S 2, off Seguine Point	Lat 40 30 30 Long 74 01 05	20	Flood	18.5	8	6.20	110
737	12.05	Near buoy S 3 in Seguine Channel	Lat 40 30 30 Long 74 11 25	1	Flood	19.0	8	6.07	110
738	12.07	Near buoy S 3 in Seguine Channel	Lat 40 30 30 Long 74 11 25	25	Flood	18.5	8	6.20	110
739	12.20	1000 feet southeast of Princes Bay light	Lat 40 30 20 Long 74 12 35	1	Flood	19.0	8	6.07	110
740	12.22	1000 feet southeast of Princes Bay light	Lat 40 30 20 Long 74 12 35	20	Flood	18.5	8	6.17	110
741	12.30	Near red buoy S 6	Lat 40 29 45 Long 74 13 35	1	Flood	19.0	8	6.00	109
742	12.32	Near red buoy S 6	Lat 40 29 45 Long 74 13 35	25	Flood	18.5	8	6.19	110
743	12.45	Near red buoy S 8	Lat 40 29 05 Long 74 14 20	1	Flood	19.0	8	6.00	109
744	12.47	Near red buoy S 8	Lat 40 29 05 Long 74 14 20	25	Flood	18.5	8	6.19	110
745	1.00	500 feet north of Great Beds light	Lat 40 29 15 Long 74 15 15	1	Flood	19.0	8	5.79	105
746	1.05	500 feet north of Great Beds light	Lat 40 29 15 Long 74 15 15	16	Flood	18.5	8	6.03	108

Dissolved Oxygen. Arthur Kills. September 21, 1909.

Low water occurred at Governors Island at 6.52 p.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen	
		Approximate	Exact					C.C. per litre	Percent satura-tion
747	1.20	Lower end of Kille, 200 feet west of buoy 3	Lat 40 30 10 Long 74 15 40	1	Flood	19.0	8	5.79	105
748	1.25	Lower end of Kille, 200 feet west of buoy 3	Lat 40 30 10 Long 74 15 40	30	Flood	18.5	8	6.02	106
749	1.40	Off Tottenville, 200 feet west of buoy S 2	Lat 40 30 55 Long 74 15 15	1	Flood	19.0	8	5.49	100
750	1.45	Off Tottenville, 200 feet west of buoy S 2	Lat 40 30 55 Long 74 15 15	45	Flood	18.0	8	5.72	102
751	2.15	Off Smoking Point, 200 feet east of buoy S A	Lat 40 33 30 Long 74 13 50	1	Flood	19.0	8	5.49	100
752	2.17	Off Smoking Point, 200 feet east of buoy S A	Lat 40 33 30 Long 74 13 50	30	Flood	18.5	8	5.72	102
753	2.35	Off Fresh Kills	Lat 40 34 20 Long 74 12 40	1	Flood	19.0	8	5.20	95
754	2.40	Off Fresh Kills	Lat 40 34 20 Long 74 12 40	26	Flood	18.5	8	5.42	97

Ex. 31. p.78

THE PEOPLE OF THE STATE OF NEW YORK v.

September 28, 1909.

High water occurred at Governors Island at 2.20 p.m. The wind was southwest, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
755	11.10	West end of Kill van Kull, near buoy S 2	Lat 40 38 30 Long 74 08 30	1	Flood	18.5	20	5.76	66
756	11.12	West end of Kill van Kull, near buoy S 2	Lat 40 38 30 Long 74 08 30	40	Flood	18.0	20	4.82	79
757	11.30	Kill van Kull off Livingston station	Lat 40 39 45 Long 74 06 50	1	Flood	18.5	20	4.34	76
758	11.32	Kill van Kull, off Livingston station	Lat 40 39 45 Long 74 06 50	20	Flood	18.0	20	4.41	76
759	11.36 p.m.	Kill van Kull, off Livingston station	Lat 40 39 45 Long 74 06 50	40	Flood	18.0	20	4.82	83
760	12.20	East end of Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 08 15	1	Flood	18.5	20	4.62	81
761	12.25	East end of Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 08 15	40	Flood	18.0	20	4.82	83
762	12.50	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 15 Long 74 03 50	1	Flood	18.5	20	4.91	86
763	12.52	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 15 Long 74 03 50	20	Flood	18.0	20	5.00	86
764	12.55	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 15 Long 74 03 50	40	Flood	18.0	20	5.12	88
765	1.05	Upper Bay, near buoy G 2	Lat 40 40 10 Long 74 03 12	1	Flood	18.5	20	4.77	84
766	1.07	Upper Bay, near buoy G 2	Lat 40 40 10 Long 74 03 12	40	Flood	18.0	20	5.00	86
767	1.15	Upper Bay, near buoy S 2, off Liberty Island	Lat 40 41 05 Long 74 02 40	1	Flood	18.5	20	4.34	76

September 22, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
			o	'	"						
768	1.17	Upper Bay, near buoy S 2, off Liberty Island	Lat	40	41 05	20	Flood	18.0	20	4.41	76
			Long	74	02 40						
769	1.18	Upper Bay, near buoy S 2, off Liberty Island	Lat	40	41 05	40	Flood	18.0	20	4.52	78
			Long	74	02 40						
770	1.25	East River, between Governors Island and Battery	Lat	40	41 50	1	Flood	18.5	20	4.19	74
			Long	74	01 00						
771	1.27	East River, between Governors Island and Battery	Lat	40	41 50	40	Flood	18.0	20	4.27	74
			Long	74	01 00						
772	1.35	East River, midstream, at Brooklyn bridge	Lat	40	42 20	1	Flood	18.5	20	4.04	71
			Long	73	59 48						
773	1.37	East River, midstream, at Brooklyn bridge	Lat	40	42 20	20	Flood	18.0	20	4.12	71
			Long	73	59 48						
774	1.40	East River, midstream, at Brooklyn bridge	Lat	40	42 20	40	Flood	18.0	20	4.22	73
			Long	73	59 48						
775	1.50	East River, midstream, at Manhattan bridge	Lat	40	42 25	1	Flood	18.5	20	3.76	66
			Long	73	59 25						
776	1.52	East River, midstream, at Manhattan bridge	Lat	40	42 25	40	Flood	18.0	20	3.92	68
			Long	73	59 25						

THE BOARD OF THE STATE OF NEW YORK

Low water occurred at Governors Island at 8.19 p.m. The wind was northwest with a velocity of 30 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
777	10.37	Upper Bay, 200 feet off Battery	Lat 40 42 10 Long 74 01 10	1	Ebb	18.5	29	4.62	78
778	10.58	Upper Bay, 200 feet off Battery	Lat 40 42 10 Long 74 01 10	40	Ebb	18.0	28	4.82	82
779	10.53	Upper Bay, 200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	1	Ebb	18.5	28	4.62	78
780	10.54	Upper Bay, 200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	20	Ebb	18.0	28	4.71	80
781	10.56	Upper Bay, 200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	40	Ebb	18.0	28	5.12	87
782	11.56	Upper Bay, near buoy G 2	Lat 40 40 10 Long 74 03 12	1	Ebb	18.5	29	4.91	84
783	11.57	Upper Bay, near buoy G 2	Lat 40 40 10 Long 74 03 12	40	Ebb	18.0	28	5.12	87
784	12.07	Upper Bay, 1000 feet west of Robbins Reef light	Lat 40 39 25 Long 74 03 45	1	Ebb	18.5	28	4.91	84
785	12.10	Upper Bay, 1000 feet west of Robbins Reef light	Lat 40 39 25 Long 74 03 45	20	Ebb	18.0	28	5.12	87

Ex. 31. p.61

Dissolved Oxygen. Kill van Kull. September 30, 1909.

Low water occurred at Governors Island at 3.19 p.m. The wind was northwest, with a velocity of 30 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
786	12.20	Kill van Kull, east end	Lat 40 39 06 Long 74 06 15	1	Ebb	18.5	28	4.62	79
787	12.22	Kill van Kull, east end	Lat 40 39 06 Long 74 06 15	20	Ebb	18.0	28	4.71	80
788	12.25	Kill van Kull, east end	Lat 40 39 06 Long 74 06 15	40	Ebb	18.0	28	5.12	87
789	12.35	Kill van Kull, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 07	1	Ebb	18.5	28	4.54	76
790	12.38	Kill van Kull, off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 07	40	Ebb	18.0	28	4.52	77
791	1.05	Kill van Kull, off Port Richmond	Lat 40 39 36 Long 74 07 52	1	Ebb	18.5	28	4.04	69
792	10.7	Kill van Kull, off Port Richmond	Lat 40 39 36 Long 74 07 52	20	Ebb	18.0	28	4.12	70
793	1.09	Kill van Kull, off Port Richmond	Lat 40 39 36 Long 74 07 52	40	Ebb	18.0	28	4.28	72
794	2.40	Kill van Kull, west end	Lat 40 38 30 Long 74 08 30	1	Ebb	18.5	28	4.04	69
795	2.43	Kill van Kull, west end	Lat 40 38 30 Long 74 08 30	40	Ebb	18.0	28	4.28	72

3552 THE PEOPLE OF THE STATE OF NEW YORK vs.

High water occurred at Governors Island at 9.23 a.m. The wind was northwest, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
796	9.50	500 feet off Pier 32, Brooklyn	Lat 40	41	10	1	Flood	18.0	28	4.62	78
			Long 74	00	30						
797	9.52	500 feet off Pier 32, Brooklyn	Lat 40	41	10	40	Flood	18.0	28	4.82	82
			Long 74	00	30						
798	10.00	At Brooklyn bridge, 500 feet off Brooklyn shore	Lat 40	42	15	1	Flood	18.0	28	4.49	76
			Long 73	59	45						
799	10.02	At Brooklyn bridge, 500 feet off Brooklyn shore	Lat 40	42	15	20	Flood	18.0	28	4.57	77
			Long 73	59	45						
800	10.04	At Brooklyn bridge, 500 feet off Brooklyn shore	Lat 40	42	15	40	Flood	18.0	28	4.82	82
			Long 73	59	45						
801	10.16	At Williamsburg bridge, 500 feet off Brooklyn shore	Lat 40	42	45	1	Flood	18.0	28	4.34	74
			Long 73	58	10						
802	10.18	At Williamsburg bridge, 500 feet off Brooklyn shore	Lat 40	42	45	40	Flood	19.0	28	4.82	77
			Long 73	58	10						
803	10.30	Opposite East 34 St., 500 feet off Brooklyn shore	Lat 40	44	20	1	Flood	19.0	28	3.76	64
			Long 73	57	45						
804	10.31	Opposite East 34 St., 500 feet off Brooklyn shore	Lat 40	44	20	20	Flood	19.0	28	4.13	70
			Long 73	57	45						
805	10.33	Opposite East 34 St., 500 feet off Brooklyn shore	Lat 40	44	20	40	Flood	19.0	28	4.22	72
			Long 73	57	45						
806	10.50	At Queensboro bridge, east channel	Lat 40	45	20	1	Flood	18.0	28	4.34	74
			Long 73	57	10						
807	10.52	At Queensboro bridge, east channel	Lat 40	45	20	40	Flood	18.0	28	4.52	77
			Long 73	57	10						
808	11.06	At Hell Gate	Lat 40	46	50	1	Flood	18.0	28	4.34	74
			Long 73	56	00						
809	11.06	At Hell Gate	Lat 40	46	50	20	Flood	18.0	28	4.41	75
			Long 73	56	00						
810	11.08	At Hell Gate	Lat 40	46	50	40	Flood	18.0	28	4.82	82
			Long 73	56	00						

Dissolved Oxygen. Long Island Sound. October 1, 1909.

Low water occurred at Governors Island at 4.07 p.m. The wind was northwest, with a velocity of 40 miles per hour. The current was flowing westward.

Sample No.	Hour p.m.	Location of Sample					Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate		Exact °	'	"	Feet below surface			C.C. per litre	Percent saturation
811	1.30	Long Island Sound, near Throgs Neck	Lat	40	48	30	1	Ebb	18.0	88	8.79	98
			Long	73	47	30						
812	1.52	Long Island Sound, near Throgs Neck	Lat	40	48	30	25	Ebb	19.0	88	8.89	100
			Long	73	47	30						
813	1.54	Long Island Sound, near Throgs Neck	Lat	40	48	30	50	Ebb	18.0	88	8.98	102
			Long	73	47	30						

No. 31. p.86

Low water occurred at Governors Island at 4.07 p.m. The wind was northwest, with a velocity of 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
614	1.06	East River, between North and South Brothers Island	Lat 40 47 56 Long 73 53 56	1	Ebb	19.0	29	4.91	68
615	1.07	East River, between North and South Brothers Island	Lat 40 47 56 Long 73 53 56	40	Ebb	18.0	29	5.12	67
616	2.15	Midstream, off East 116 St. Harlem River	Lat 40 47 38 Long 73 55 30	1	Ebb	19.5	29	3.76	64
617	2.15	Midstream, off East 116 St. Harlem River	Lat 40 47 38 Long 73 55 30	30	Ebb	18.5	29	3.92	66
618	2.08	Midstream, off East 110 St., Harlem River	Lat 40 47 20 Long 73 56 05	1	Ebb	18.5	29	3.76	64
619	2.07	Midstream, off East 110 St. Harlem River	Lat 40 47 20 Long 73 56 05	30	Ebb	18.5	29	3.92	66
620	2.58	Hell Gate, off East 90 St. East River	Lat 40 46 40 Long 73 56 20	1	Ebb	18.0	29	4.62	78
621	2.56	Hell Gate, off East 90 St. East River	Lat 40 46 40 Long 73 56 20	30	Ebb	18.0	29	4.71	80
622	2.59	Hell Gate, off East 90 St. East River	Lat 40 46 40 Long 73 56 20	40	Ebb	18.0	29	4.62	78
623	2.47	At Queensboro bridge, west channel, East River	Lat 40 45 25 Long 73 57 30	1	Ebb	18.0	29	4.94	74
624	2.50	At Queensboro bridge, west channel, East River	Lat 40 45 25 Long 73 57 30	40	Ebb	18.0	29	4.62	92
625	3.06	1000 feet off mouth of Newtown Creek, East River	Lat 40 44 10 Long 73 57 55	1	Ebb	18.5	29	3.10	54
626	3.10	1000 feet off mouth of Newtown Creek, East River	Lat 40 44 10 Long 73 57 55	30	Ebb	19.0	29	3.61	61

Ex. 31. p.60

Dissolved Oxygen. East River and Harlem River. (Continued.)

October 1, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Lat. °	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
827	3.28	1000 feet off Wallabout Bay, East River	Lat 40 42 25 Long 73 59 3[illegible]			1	Ebb	19.8	29	3.47	49
828	3.30	1000 feet off Wallabout Bay, East River	Lat 40 41 25 Long 73 59 3[illegible]			10	Ebb	19.0	28	3.82	48
829	3.32	1000 feet off Wallabout Bay, East River	Lat 40 42 25 Long 73 59 3[illegible]			40	Ebb	19.[illegible]	28	4.22	58

Ex. 31. p.86

High water occurred at Governors Island at 10.19 A.M. The wind was west, with a velocity of 20 miles per hour.

Sample No.	Hour A.M.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percentage saturation
830	9.27	500 feet off Pier 4, Manhattan	Lat	40 42 00		1	Flood	17.0	29	4.62	79
			Long	74 00 40							
831	9.31	500 feet off Pier 4, Manhattan	Lat	40 42 00		20	Flood	17.0	28	4.71	79
			Long	74 00 40							
832	9.35	500 feet off Pier 4, Manhattan	Lat	40 42 00		40	Flood	17.0	28	4.82	81
			Long	74 00 40							
833	9.38	At Brooklyn bridge, 500 feet off Manhattan shore	Lat	40 42 25		1	Flood	17.0	29	4.84	73
			Long	73 59 55							
834	9.39	At Brooklyn bridge, 500 feet off Manhattan shore	Lat	40 42 25		40	Flood	17.0	29	4.82	79
			Long	73 59 55							
835	9.80	At Williamsburg bridge, 500 feet off Manhattan shore	Lat	40 42 30		1	Flood	17.0	28	4.04	68
			Long	73 58 30							
836	9.82	At Williamsburg bridge, 500 feet off Manhattan shore	Lat	40 42 30		20	Flood	17.0	28	4.12	69
			Long	73 58 30							
837	9.86	At Williamsburg bridge, 500 feet off Manhattan shore	Lat	40 42 30		40	Flood	17.0	29	4.22	71
			Long	73 58 30							
838	10.18	Opposite East 34 St., 500 feet off shore	Lat	40 44 30		1	Flood	17.0	18	3.90	66
			Long	73 58 15							
839	10.18	Opposite East 34 St., 500 feet off shore	Lat	40 44 30		40	Flood	17.0	28	4.00	67
			Long	73 58 15							
840	10.30	At Queensboro bridge, West channel	Lat	40 45 25		1	Flood	17.0	28	4.04	68
			Long	73 57 30							
841	10.31	At Queensboro bridge, west channel	Lat	40 45 25		20	Flood	17.0	28	4.12	69
			Long	73 57 30							
842	10.33	At Queensboro bridge, west channel	Lat	40 45 25		40	Flood	17.0	28	4.22	71
			Long	73 57 30							

Ex. 21. p.87

Dissolved Oxygen. East River. (Continued.) October 2, 1909.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
843	10.40	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 20	1	Flood	17.0	28	4.04	68
844	10.41	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 20	20	Flood	17.0	28	4.12	69
845	10.43	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 20	40	Flood	17.0	28	4.52	76

Ex. 31. p.88

High water occurred at Governors Island at 12.41 p.m. The wind was northwest, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent asturation
846	10.55	1/5 way across from foot of West 42 St.	Lat 40 45 50 Long 74 00 20	1	Flood	17.0	52	4.91	78
847	10.56	1/5 way across from foot of West 42 St.	Lat 40 45 50 Long 74 00 20	20	Flood	17.0	52	5.00	79
848	10.57	1/5 way across from foot of West 42 St.	Lat 40 45 50 Long 74 00 20	40	Flood	17.0	52	5.12	81
849	11.05	2/5 way across from foot of West 42 St.	Lat 40 45 55 Long 74 00 30	1	Flood	17.0	52	5.20	83
850	11.07	2/5 way across from foot of West 42 St.	Lat 40 45 55 Long 74 00 30	20	Flood	17.0	52	5.29	84
851	11.09	2/5 way across from foot of West 42 St.	Lat 40 45 55 Long 74 00 30	40	Flood	17.0	52	5.42	86
852	11.15	3/4 way across from foot of West 42 St.	Lat 40 46 00 Long 74 00 50	1	Flood	17.0	52	5.49	87
853	11.17	3/4 way across from foot of West 42 St.	Lat 40 46 00 Long 74 00 50	20	Flood	17.0	52	5.59	89
854	11.19 p.m.	3/4 way across from foot of West 42 St.	Lat 40 46 00 Long 74 00 50	40	Flood	17.0	52	5.72	91
855	12.15	1/5 way across from foot of West 137 St.	Lat 40 49 30 Long 73 57 35	1	Flood	17.0	52	5.20	83
856	12.16	1/5 way across from foot of West 137 St.	Lat 40 49 30 Long 73 57 35	20	Flood	17.0	52	5.29	84
857	12.18	1/5 way across from foot of West 137 St.	Lat 40 49 30 Long 73 57 35	40	Flood	17.0	52	5.42	86
858	12.28	2/5 way across from foot of West 137 St.	Lat 40 49 35 Long 73 57 50	1	Flood	17.0	52	5.20	83
859	12.29	2/5 way across from foot of West 137 St.	Lat 40 49 35 Long 73 57 50	20	Flood	17.0	52	5.29	84
860	12.30	2/5 way across from foot of West 137 St.	Lat 40 49 35 Long 73 57 50	40	Flood	17.0	52	5.42	86

THE STATE OF NEW JERSEY ET AL. 23556

Dissolved Oxygen. Hudson River Cross-sections. (Continued.) October 5, 1909.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
861	12.40	3/4 way across from foot of West 137 St.	Lat 40 49 40 Long 73 58 05	1	Flood	17.0	52	5.49	87
862	12.41	3/4 way across from foot of West 137 St.	Lat 40 49 40 Long 73 58 05	20	Flood	17.0	52	5.59	89
863	12.43	3/4 way across from foot of West 137 St.	Lat 40 49 40 Long 73 58 05	25	Flood	17.0	52	5.72	91
864	1.20	500 feet off Inwood.	Lat 40 52 20 Long 73 55 55	1	Flood	17.0	52	5.49	87
865	1.21	500 feet off Inwood.	Lat 40 52 20 Long 73 55 55	20	Flood	17.0	52	5.59	89
866	1.23	500 feet off Inwood.	Lat 40 52 20 Long 73 55 55	40	Flood	17.0	52	5.72	91
867	1.33	1/3 way across from Inwood	Lat 40 52 25 Long 73 56 05	1	Flood	17.0	52	5.49	87
868	1.34	1/3 way across from Inwood	Lat 40 52 25 Long 73 56 05	20	Flood	17.0	52	5.89	94
869	1.36	1/3 way across from Inwood	Lat 40 52 25 Long 73 56 05	40	Flood	17.0	52	6.02	96
870	1.46	2/3 way across from Inwood	Lat 40 52 35 Long 73 56 25	1	Flood	17.0	52	5.79	92
871	1.47	2/3 way across from Inwood	Lat 40 52 35 Long 73 56 25	20	Flood	17.0	52	5.89	94
872	1.49	2/3 way across from Inwood.	Lat 40 52 35 Long 73 56 25	25	Flood	17.0	52	6.02	96

COMPLAINANTS' EXHIBIT No. 44. James D. Maher, Commissioner.

Float Observations.

October 26, 1908.

Dr. George A. Soper, President Metropolitan Sewerage Commission of N. Y., New York City.

DEAR SIR: I beg to report as follows results of float observations made in the Harlem River in August and September.

From the N. Y. C. & H. R. R. R. bridge at Spuyten Duyvil to a point nearly opposite East 125th St. the Harlem River is 6½ miles long. In round figures the different bridges are the following distances from the Spuyten Duyvil bridge:

Spuyten Duyvil	Bridge	0	mi.
Broadway (Kingsbridge)	"	1	"
University Heights (207th St.)	"	2	"
Washington (131st St.)	"	3¼	"
High	"	3½	"
Putnam (6th Ave.)	"	4 3/5	"
Central (McComb's Lane)	"	4½	"
Lenox Ave. (145th St.)	"	5⅛	"
Madison Ave. (Mott Haven)	"	5½	"
Park Ave. (N. Y. C. & H. R. R. R.)	"	5¾	"
Third " (131st St.)	"	6	"
Second Ave. (129th St.)	"	6⅛	"
First " (Willis Ave.)	"	6¼	"

Data Obtained from Float Observations in the Harlem River.

Float No.	5.	6.	7.	8.	11.	12.	13.	14.	24.
Date, —, 1908	Aug. 17.	Aug. 18.	Aug. 19.	Aug. 20.	Aug. 25.	Aug. 26.	Aug. 27.	Aug. 28.	Sept. 9.
H. W. G. I.	0.21 P. M.	1.19 P. M.	2.17 P. M.	3.15 P. M.	7.21 A. M.	7.50 A. M.	8.19 A. M.	8.46 A. M.	6.51 A. M.
L. W. G. I.	6.12 A. M.	7.08 A. M.	8.05 A. M.	9.05 A. M.	1.20 P. M.	1.57 P. M.	2.31 P. M.	3.03 P. M.	1.06 P. M.
Records during Flood Current:									
Start — number of miles from Spuyten Duyvil Bridge	0	5⅛	0	3¼	....	....	....	....	....
Time after L. W. G. I.	2 hr. 31 m.	1 hr. 12 m.	1 hr. 34 m.	1 hr. 39 m.	....	....	....	....	....
Miles traversed	6.05	Not continuous	Not continuous Est'd 4.70	4.05	....	....	....	....	....
Time consumed	4 hr. 52 m.	6 hr. 30 m.	6 hr. 02 m.	4 hr. 51 m.	....	....	....	....	....
Mean vel.—mi. per hr.	1.24	....	Est. 0.78	0.89	....	....	....	....	....
Max. " " " "	2.35	1.80	1.93	1.31	....	....	....	....	....
Where maximum velocity occurred in miles from Spuyten Duyvil Bridge	3⅜	6⅜	0¾	5⅞	....	....	....	....	....
Beginning of Flood Current:									
Time after L. W. G. I.	2 hr. 1* m.	1 hr. 10 m.	1 hr. 35 m.	1 hr. 40 m.	....	....	1 hr. 35 m.	....	....
Miles from Sp. Duy. Br.	0	5⅛	0	3¼	....	....	0	....	....
Records during Ebb Current:									
Start—number of miles from Spuyten Duyvil Bridge	5½	....	....	....	5¼	6	6⅝	8¼**	....
Time after H. W. G. I.	1 hr. 19 m.	....	....	....	1 hr. 28 m.	1 hr. 10 m.	1 hr. 17 m.	1 hr. 44 m.	....
Miles traversed	4.3	....	....	....	5.39	6.28	6.95	5.25	....
Time consumed	3 hr. 0 m.	....	....	....	3 hr. 45 m.	4 hr. 05 m.	5 hr. 16 m.	5 hr. 36 m.	....
Mean vel.—mi. per hr.	1.43	....	....	....	1.43	1.54	1.30	0.94	....
Max. " " " "	2.35	....	....	....	2.50	2.04	2.36	1.50†	....
Where maximum velocity occurred in miles from Spuyten Duyvil Bridge	1¼	....	....	....	0	3¾	3.00	5⅝ & 6	....
Beginning of Ebb Current:									
Time after H. W. G. I.	1 hr. 20 m.	1 hr. 30 m.	1 hr. 25 m.	0 hr. 25 m.	1 hr. 30 m.	1 hr. 10 m.	1 hr. 15 m.	1 hr. 45 m.	1 hr. 40 m.
Miles from Sp. Duy. Br.	5½	6	5¾	7⅛	5¼	6	6⅝	8¼**	0½

* Approximate only. This time was not observed.

† A velocity of 1.80 was also observed in this float in the Bronx Kills.

** North West of North Brothers Island.

3 The following statement comprises a summary of the principal facts regarding the float records as observed in the Harlem River.

NOTE.—Here and in the following discussion—

High Water at Governors Island is indicated by H W G I
and Low " " " " " " " " L W G I

From an inspection of this table the following inferences may be drawn, subject to modification with a greater number of records.

1. The flood current in the Harlem begins to run about an hour and a half after predicted L W G I.

2. The ebb current begins about an hour and a half after H W G I but progresses from the south end of the river northward as indicated by the following figures:

At 116th St..... 0 hr. 25m. after H W G I
" 122nd " ..... 1 " 15 " " "
" 131st " $\frac{1.10 + 1.30}{2}$ ..... 1 " 20 " " "
" 135th " ..... 1 " 25 " " "
" 139th " ..... 1 " 20 " " "
" 142nd " ..... 1 " 30 " " "
" 219th " ..... 1 " 45 " " "

3. The mean flood velocity appears to vary from ¾ mi. to 1¼ miles per hour, (1.1 to 1.8 ft. per sec.).

4. The mean ebb velocity approximates 1.4 miles per hour or 2.0 feet per second.

5. The maximum velocity varies with the cross-section of the channel, but in general it may be taken as about 2.35 miles
4 per hour or 3.45 feet per second on the ebb.*

On the flood a velocity of 2.35 was noted once, the other maxima falling below 2 mi. per hour, indicating an ordinary maximum less than that in the ebb current.

6. The path of float No. 3 represents the flow of an entire flood tide, that of float No. 5 nearly an entire flood tide, and that of No. 7 represents the flow of an entire ebb tide. The path of float No. 13 (ebb) extends the entire length of the Harlem under consideration (north of Bronx Kills), while those of Nos. 5 and 7 extend over

*See note page 4.

nearly all of this distance. Float No. 6 showed a strong current flowing to the east through Bronx Kills and Little Hell Gate; floats 11, 12 and 13 passed into and down the Hudson; while No. 14 would have turned back in the Harlem between the Washington and University Heights Bridge on the arrival of the flood current. The distances traversed in the Harlem are:

Float No.	Flood.	Ebb.
5	6.05	
7	4.70	
8	4.05	
13	.....	8.95
Average of all mean velocities observed	0.97	1.33

$$\frac{\text{Distance traversed on ebb}}{\text{Average distance traversed on flood}} = \frac{6.95}{4.93} = 1.41$$

$$\frac{\text{Average of mean ebb velocities}}{\text{Average of mean flood velocities}} = \frac{1.33}{0.97} = 1.37$$

5 NOTE.—Assuming the above figures as correct there follows:

$$\frac{\text{Mean veloc.}}{\text{Max. veloc.}} \quad \frac{2}{3.45} \quad 0.58$$

According to the zin curve.... $\left\{\frac{\text{Mean veloc.}}{\text{Max. veloc.}} \quad \frac{2}{} \quad 0.64\right.$

These figures indicate:

a. That the general trend of sewage discharged into the Harlem River is toward the Hudson River.

b. That the general progression in this direction is from one to two miles per tide.

c. That the preponderance of discharge into the Hudson River over that into the East River may be taken provisionally at 40 per cent.

d. That practically the entire contents of the Harlem River at the end of the flood pass into the Hudson River during the ebb and that over half the contents at the end of the ebb pass into the East River during the flood.

The duration of slack water on either tide is shown to be short by the records of floats Nos. 6, 7, 8, 11, 12 & 13, as a rule not exceeding about fifteen minutes.

Although affected somewhat by the wind (see floats Nos. 5, 7) and so in some instances driven toward the shore, there seems to be no general tendency in this direction. On the contrary it is probable that floating matter generally follows the channel of the stream,
and so finds a free exit to either the East or Hudson River.
6 The normal tidal current, however, is subject to variation, not only by the effect of the wind near the surface, but by the passage of vessels, the obstruction of piers and by the continual change in cross-section. In those reaches where the cross-section is constricted and the channel straight and uniform—as in the Ship Canal—a higher velocity will naturally obtain than where the opposite conditions are found.

The velocity of the float depends, not only on the above matters, but to a very considerable extent upon the part of the stream traversed. If near the shore the velocity may be greatly retarded. The mean and maximum velocities indicated by the floats are therefore likely to be less than the actual velocities they represent.

In Appendix 9 of the report of the U. S. C. & G. S. of 1888 the elevation of the Hudson at 42nd St. and of the East River at Pelhemus Dock are given for each lunar hour. The mean elevation in the Hudson for the entire period is 0.02 above the mean sea-level at Sandy Hook and that of the East River 0.20 below that datum the resultant elevation in the Hudson being 0.22 above that in the East River.

By scaling from automatic tide gage records of the Dock Department for 24 hours from 10 p. m. April 24, 1908, taken at 131st St. in the Hudson and at Astoria in the East River the differences are more marked, the mean elevation of the Hudson being 0.30 above that in the East River.

These results, arrived at from independent sources, would
7 lead one to expect a preponderance of flow from the Hudson through the Harlem to the East River.

By superimposng tide gage records taken simultaneously at 131st St. on the Hudson and Astoria on the East River it will be seen that the tide changes first in the Hudson and is of less amplitude than in the East River, also that the times of slack water in the Hudson River as observed by us occur very nearly at the times of equal elevation in the Hudson and East Rivers, indicating that the flow through the Harlem is truly "hydraulic" in character, that is, dependent in amount on the surface slope for its magnitude. For this

reason sewage discharged from the Harlem River is carried by the ebb toward the Sound in the East River and by the ebb down the Hudson and not in the reverse direction until the tide changes. The vertical distance between the two curves at any time represents the differences in elevation of the respective water surfaces at the time. It will also be observed that while this difference is greater during the flood tide the actual elevation of the surfaces is greater during the ebb. This last difference amounts to 0.67 by the above records and to 1.36 according to the figures contained in the U. S. C. & G. S. report above referred to. This means that during the ebb the cross-section of the water in the Harlem is greater than during the flood, tending to counteract the effect of the .2 or .3 higher average elevation of the Hudson. Then, too, the flood current is subject to a certain throttling in the constricted channel between Spuyten
8 Duyvil and Kingsbridge, while the entrance from near Randall's Island is more free and unobstructed. The relative values of these different factors it is impracticable to estimate owing to the irregular and variable character of the cross-section of the Harlem, and we must rely on the evidence of actual observations, as by floats, current meters, etc.

If we assume that the distance traversed by the flood current is 4.93 miles and that by the ebb is 6.95 miles, and if we take 12,600 sq. ft. as the mean cross-section of the Harlem River at mid tide,* the discharge into the East River during every flood tide is about 328 million cubic feet and that into the Hudson River 462 million cubic feet.

9 In view of the apparent anomaly of an excess of flow toward the stream having the higher average surface level the results of the small number of experiments by which this excess toward the Hudson is indicated should be confirmed by further observations before accepting them as final. On account of the narrow width of the Harlem, its obstruction by bridges, the interference of traffic, all of which interfere with the normal motion of a float, I recommend that a gauging of the stream be made to settle this question. To avoid the interference of traffic as much as possible, as well as the disturbance due to bridges, piers and other structures, such a gaging could best be undertaken toward the northern end of the stream, and a most favorable location would appear to be in the Harlem Ship Canal, where the channel is fairly uniform as to depth and width. In any plan adopted the necessity of avoiding interference with traffic has to be borne in mind.

To obtain the most reliable results expeditiously such a gaging should be done by the use of a current meter. If this plan is adopted

---

* An average of cross-section as scaled from the Coast Survey chart below the Broadway, High, Central and Park Avenue Bridges.

the stream should be cross-sectioned by soundings every 10 feet at the proposed location. The instrument can be operated from a launch anchored on a range line at right angles to the shore and located in position by observation from, or ranges set by, a transit at the end of a measured base on one shore. As the mean velocity is generally found at from 55 to 65% of the depth I would take the observations at a point 60% of the depth continuously or, at least, for 20 minutes each hour, for a complete cycle of the tide. By this method a complete integration of all the fluctuating velocities flowing water is subject to may be secured for each station on the desired cross-section, such stations being perhaps 50 feet apart, making zone 7 stations in all.

Such a series of observations would occupy 15 actual working days and is estimated to cost as follows, allowing one extra day for launch on account of bad weather:

Launch, Captain and one man,	at	$17.00 per day	$240.
Transit man	at	5.00 " "	70.
Observer	at	7.00 " "	98.
Current meter, material, etc.			175.
Cross-sectioning stream, etc.			42.
			$625.00

If a current meter could be borrowed this amount would be correspondingly reduced.

A somewhat simple though not so accurate a gaging may be made by timing the passage of vertical float rods between two cross-sections 100 or 200 feet apart. The reason this is not so accurate a method is, first, that the rod cannot be of such a length as to represent the mean velocity, secondly, that the rods will not float in parallel directions between the two cross-sections but will be influenced by local eddies and cross currents, and, thirdly, because the cross-section of the channel itself is constantly changing between the upper and lower cross-sections. However, it is believed that this method would furnish results that will not vary from the true gaging as much as any one gaging may vary from another made under other conditions, (of fresh water in the Hudson, phase of the moon, etc.)

With rods 12 ft. long weighted at the lower end, 7 starting points, and observations hourly from each point, the estimated cost would be, allowing for one day extra for launch on account of rain:

10 floats		at	$1.00.....	$10.
Launch and crew,	6 days	at	16.00.....	96.
Transitman	5 "	"	5.00.....	25.
Starter	5 "	"	4.00.....	20.
Man in rowboat to recover floats	5 "	"	2.00.....	10.
Preparatory instrumental work, cross-sectioning, etc.....				49.
Total.....				$210.

Very respectfully,

_____,

Chief Engineer.

COMPLAINANTS' EXHIBIT No. 51. James D. Maher, Commissioner.

Float Observations.

NEW YORK, November 19, 1908.

Dr. George A. Soper, President Metropolitan Sewerage Commission, New York City.

DEAR SIR: I beg to report as follows the results of float observations made by this Commission in the East River south of Hell Gate. The following are in round numbers the distances of important points from the north end of Governor's Island:

Brooklyn Bridge	1.3	miles.*
Manhattan "	1.6	"
Wallabout Channel	2.5	"
Williamsburgh Bridge	2.8	"
Newtown Creek	4.5	"
South end Blackwell's Is	5.5	"
North " " "	7.4	"
Mill Rocks and Hallet's Point	7.9	"

The accompanying table comprises a summary of the principal facts regarding observations on two floats made in 1907 and six floats in 1908 in this part of the East River, from which the following inferences may be drawn.

*In this discussion where the word "miles" occurs it is intended to mean "statute" miles and not "nautical" miles.

				Data Obtained.				
Float No.	10	16	23	27	28	29		
Date, —, 1908	Aug. 24.	Aug. 31.	Sept. 8.	Sept. 12.	Oct. 3.	Oct. 5.	Mar. 7, '07.	Mar. 29, '07.
H. W. G. I.	6.45 A. M.	10.25 A. M.	3.51 A. M.	9.20 A. M.	{ 12.46 A. M. / 1.31 P. M. }	3.55 P. M.	{ 1.34 A. M.* / 2.00 P. M. }	8.02 A. M.
L. W. G. I.	12.38 P. M.	4.50 P. M.	12.10 P. M.	{ 3.15 A. M. / 3.41 P. M. }	7.11 A. M.	9.53 A. M.	8.00 A. M.	2.28 P. M.

				Flood Records.				
Start, No. mi. from N. end Gov. Is.	0	.....	.....	7/8	1½	0	3/4	.....
Time after L. W. G. I., 1 h. 2 m.	.....	.....	.....	5 h. 10 m.	5 h. 36 m.	5 h. 18 m.	2 h. 25 m.	.....
Miles traversed	.....	.....	.....	4.63	5.64	5.36	8.0	.....
Time consumed	.....	.....	.....	2 h. 21 m.	2 h. 47 m.	2 h. 37 m.	4 h. 47 m.	.....
Mean v. mi. per hr.	.....	.....	.....	1.97	2.02	2.05	1.67	.....
Max. v. " " "	.....	.....	.....	3.53	6.80	3.97	2.5	.....
Where max. vel. occurred, mi. from N. end Gov. Is.	.....	.....	.....	1.6 to 2.1	2.2	1.7	3.1 to 3.5	.....
Beginning of Flood Current:								
Time after L. W. G. I.	.....	.....	.....	.....	.....	.....	.....	.....
Mi. from N. end Gov. Is.	.....	.....	.....	.....	.....	.....	.....	.....

				Ebb Records.				
Start, No. mi. from N. end Gov. Is.	9.	8.	7⅞	8½	8.	.....	.....	In Hell Gate. 8⅝
Time after H. W. G. I.	2 h. 25 m.	4 h. 38 m.	2 h. 50 m.	1 h. 26 m.	3 h. 9 m.	.....	.....	1 h. 58 m.
Miles traversed	9.7	7.	7.628	5.63	7.42	.....	.....	8.8
Time consumed	4 h. 50 m.	1 h. 24 m.	2 h. 5 m.	2 h. 36 m.	3 h. 25 m.	.....	.....	2 h. 50 m.
Mean v. mi. per hr.	2.16	3.63	3.70	2.32	2.17	.....	.....	3.1
Max. v. " " "	5.08	8.57	6.00	4.05	5.70	.....	.....	.....
Where max. vel. occurred, mi. from N. end Gov. Is.	W. Chan. 6 to 7	N. of W. Ch. 7.4 to 7.9	5.3 to 6.0	Close to N. side. 1.0 to 1.3	2.1	.....	.....	.....
Beginning of Ebb C't:								
Time after H. W. G. I.	.....	.....	.....	1 h. 25 m.	3 h. 10 m.	1 h. 50 m.	1 h. 45 m.	.....
Mi. fr. N. end Gov. I.	.....	.....	.....	3½	8.	5.	9.0 in Hell Gate.	.....

* This float went aground and had to be set out again twice.

THE FLOATS OF THE STATE OF NEW YORK (S. 2270)

1 1. The ebb current may be expected to set:

	h m.		
Ebbing between Williamsburgh bridge and Newtown Creek at	1 25	after	H. W. G. I.
Ebbing between Newtown Creek and Blackwell's Island at	1 50	"	"
Southeast of Ward's Island	1 45	"	"

The turn of the tide indicated by Float No. 38 in Hell Gate just northeast of Hallet's Point 3 h. 10 m. after H. W. G. I. is difficult to explain and would indicate that the time of slack water is subject to a considerable variation in this vicinty. The moderate north wind blowing at this time would not account for such a difference between the times noted here and those at other points.

2. The mean velocity of the flood may be taken as 2 miles per hour (3 ft. per sec.).

3. The mean velocity of the ebb may be taken provisionally at 2.8 miles per hour (4 ft. per sec.), this being an average of five ebb reads extending over 7 miles in length, but as these vary from 2.16 to 3.70 miles per hour it may be that the velocity depends to a large degree upon the part of the channel traversed.

4. The maximum flood current is for short intervals and certain localities at least 6.8 miles per hour (10 ft. per sec.), but for any considerable distance and interval probably 4 miles per hour (6 ft. per sec.) would be a fair and usual figure.

5. The maximum ebb current noted was 8.57 miles per hour (12½ ft. per sec.) in approaching the channel west of Blackwell's Island from the north. For any considerable distance and interval 6 miles per hour (9 ft. per sec.) would probably be nearer the truth.

4 On account of the high velocities prevailing in this part of the East River the time taken to traverse the 7 or 8 miles is less than a complete ebb or flood tide as shown in the following figures:

Float (Mar. 7, 1907),	covered	8	miles	in	4h.	47m.	of	flood.
" No. 38	"	5.64	"	"	2h.	47m.	"	"
" No. 39	"	5.36	"	"	2h.	37m.	"	"
Float (Mar. 29, 1907),	covered	8.8	miles	in	2h.	50m.	of	ebb.
" No. 10	"	9.7	"	"	4h.	30m.	"	"
" No. 23	"	7.68	"	"	2h.	5m.	"	"
" No. 38	"	7.42	"	"	3h.	25m.	"	"

This renders it impossible to arrive at precise figures for the mean velocity of the flood or ebb current or for the discharge of the stream at each tide. It is probable that owing to the fact that the flow is "hydraulic" or directly dependent upon the difference in head between Willet's Point and Governor's Island, the velocity and discharge vary to a considerable extent from the influence of the winds on the tidal elevations at those points.

We may be reasonably justified, however, in concluding from the results shown above and by reference to the plotted paths of the floats:

a. That there is a predominance of discharge to the harbor from Long Island Sound through the East River.

b. That, on account of the high mean velocities a volume equivalent to the contents of the East River south of Hell Gate passes out at each tide, that is, four times a day. It should be remembered, however, that the greater part of this water so discharged enters again on the following return of the tide.

c. That while the bulk of the sewage contained in the East River at the beginning of the flood current will find its way to the east of Hell Gate it is not likely to go far in this direction, but will eventually pass to the southward and through the Narrows to the ocean.

d. That the trend of the flood current may take the contents of the lower East River past the eastern channel at Blackwell's Island (Float 38), but that the main current from Hell Gate south passes through the western channel. (Floats of March 29 and Nos. 10, 16 and 38).

e. That the ebb current may pass to the west (Floats of March 29 and No. 23) or to the east (Floats Nos. 27 and 38) of Governor's Island.

f. That the duration of slack water is very brief (Floats Nos. 10, 27, 38).

g. That on account of the velocities, the predominance in one direction and the brief periods of slack water the bed of the East River south of Hell Gate is kept well scoured and free from extensive deposits except near the piers.

h. That there is an apparent tendency for floating matter to work in toward the Brooklyn shore on the flood current (Floats of March 7th and Nos. 10 and 38). It is possible that this is due in part to the wind, but the tendency is not shown by the ebb records.

NOTE.—The records of Float No. 38 is of particular interest as showing the nearly continuous path of the float during a complete cycle of the tidal flow. It was set adrift in the middle of the west channel opposite the north end of Blackwell's Island at 3.02 A. M. By 3.55 A. M. it had drifted ¾ mile into Hell Gate northeast of Hallet's Point. Here the ebb flow began, carrying it to 200 ft. south of Mill Rocks by 4.07 A. M., thence, with velocities increasing to 4½ miles per hour, by the channel west of Blackwell's Island and then following the middle of the river to the south side of 6 Wallabout bay by 6.38 A. M. From here it followed the eastern side of the river to the Manhattan bridge passing over 1,000 feet in 2 minutes (5.7 mi. per hour—its maximum velocity), 2,165 ft. in 6 minutes (4.1 mi. per hour) and 3,115 ft. in 8 minutes (4.4 miles per hour). From here the path swerved toward the center of the river and at 7.12 A. M. the float was 1,000 feet northeast of Governor's Island and had traversed the last 2.62 miles in 40 minutes, or at a rate of 3.93 miles per hour. Passing down the west side of Buttermilk Channel the float reached a point 1.2 miles south of Governor's Island and about a mile west of the pier head line just south of Gowanus Canal at 8.44 A. M. Here, due in part to a strong west wind, at slack tide, the float drifted ¾ mile toward the shore with a velocity of about 2 miles per hour and then at 9.37 A. M. turned northerly on the flood current. This, with the wind, carried it up the Buttermilk Channel close to the pierhead line with velocities increasing quite uniformly to 2 miles per hour by 12.47 P. M., when it reached the Brooklyn bridge. Between this point and the Atlantic Basin (11.55 A. M.) it had run ashore five times and had been reset from 100 feet to 300 feet out. At the Brooklyn bridge it was reset about 750 feet from the east pier and from here traversed 1.45 miles in 20 minutes or at the rate of 4.35 miles per hour, the maximum velocity of 6.8 miles per hour occurring in a distance of .34 miles opposite the Wallabout Basin. Here the float crossed from the west to the east side of the river which it followed until past Newtown Creek at 1.54 P. M. From here it swerved toward midstream but passed up the east channel close to the Blackwell's Island shore, reversing its direction sharply with the turn of the tide at 3.34 P. M. 1.35 miles below its position at the beginning of the previous ebb flow, and ¾ mile above the Blackwell's Island bridge, which it

reached again on the ebb current at 4.18 P. M. The total distance traveled was 20.4 miles in 13 hours 16 minutes. Of this 10.39 miles were traversed on the ebb in 5 hours 42 minutes at a mean velocity of 1.82 miles per hour, and 9.11 miles were traversed on the flood in 5 hours 54 minutes at a mean velocity of 1.54 miles per hour.

Respectfully submitted,
(Signed) KENNETH ALLEN.

1 COMPLAINANTS' EXHIBIT No. 57. James D. Maher, Commissioner.

Float Observations.

Copy.

NOVEMBER 9, 1908.

Dr. George A. Soper, President Metropolitan Sewerage Commission, New York City.

DEAR SIR: I beg to report as follows the results of float observations made in the East River between Hell Gate and Long Island Sound during August and september.

This portion of the East River receives from the west the waters of the lower portion of the East River and the Harlem River through Hell Gate, Little Hell Gate and Bronx Kills—three channels formed by Ward's and Randall's Islands: and from the east the waters of Long Island Sound.

From a point in the East River at the south end of the Harlem, between Hallet's Point and Mill Rocks, the distances to prominent points in the East River toward Long Island Sound are:

Mill Rocks and Hallet's Point	0	mi.*
Sunken Meadow	1¾	"
North & South Brother's Islands	2¾	"
North End of Riker's Island	3¼	"
Hunt's Point	4⅛	"
College Point	5⅛	"
Closson Point	5⅝	"
Tallman Point	5⅞	"
Old Ferry Point	6½	"
Whitestone Point	6¾	"
Between Ft. Schuyler & Willet's Pt.	8¾	"

*In this discussion, wheree the word "miles" occurs it is intended to mean "statute" miles and not "nautical" miles.

Data Obtained.

Float No.	14.	15.	16.	17.	18.	19.	25.
H. W. G. I.	8.46 A. M.	Aug. 29.	Aug. 31.	Sept. 1.	Sept. 2.	Sept. 3.	Sept. 10.
Date, 1908	Aug. 28.	9.16 A. M.	10.25 A. M.	11.08 A. M.	11.57 A. M.	12.52 P. M.	7.40 A. M.
L. W. G. I.	3.03 P. M.	3.26 A. M.	4.23 A. M. 4.50 P. M.	4.56 A. M.	5.38 A. M.	6.27 A. M.	2.00 P. M.

Records During Northeasterly Current.

Start, No. mi. from Mill Rocks Is.	0	....	2½	2¾	3½	6¾	
Time after L. W. G. I.	5 h. 37 m.	5 h. 16 m.	4 h. 52 m.	4 h. 19 m.	3 h. 7 m.	2 h. 29 m.	
Miles traversed	2.99	2.82	1.54	3.65	4.41	2.85	
Time consumed	1 h. 56 m.	2 h. 23 m.	1 h. 45 m.	3 h. 20 m.	4 h. 55 m.	4 h. 04 m.	
Mean vel. mi. per hr.	1.55	1.18	0.88	1.10	0.90	0.71	
Max. " " " "	4.00	2.55	1.41	3.60	2.08	1.31	
Where max. occurred, mi. from Mill Rock Is.	1½	2⅞	3¼	3½	5⅝ to 6½	8⅝	
Beginning of N. E. current:							
Time after W. G. I.	.....	....	....	....	....	....	
Miles from M. R. Is.	.....	....	....	....	....	....	

Records During Southwesterly Current.

Start, No. mi. fr. Mill Rocks Id.	3⅜	6⅞	7¾	6¾	
Time after H. W. G. I.	2h. 15 m.	3 h. 29 m.	1 h. 51 m.	2 h. 15 m.	
Miles Traversed	3.28	1.12	0.53	6.85	
Time consumed	2 h. 23 m.	0 h. 53 m.	2 h. 02 m.	5 h. 48 m.	
Mean vel. mi. per hr.	1.37	1.27	0.26	1.18	
Max. " " " "	5.00	1.37	0.46	1.98	
Where max. vel. occurred. mi. from Mill Rocks Id.	½ to 1½	5¾ to 6¾	7⅜	5½	
Beg. of S. W. current:					
Time after H. W. G. I.**	2 h. 15 m.	.....	1 h. 50 m.	0 h. 0 m.	1 h. 02.05*
Mi. fr. M. R. Id.	3⅜	.....	7¾	9½	6¾

* Not observed. **1 h. 45 m. for Float No. 14.

The principal data resulting from float observations in this vicinity are comprised in the attached table.

The small number of float records taken in this part of the East River do not warrant very positive statements as to the results. The presence of Islands near the western end with the influence of the currents to or from the Harlem River render the hydraulic phenomena here complicated and constantly varying, while the tortuous paths of the floats indicate the absence of any one main channel which conveys at all times the greater part of the discharge. An inspection of the Coast Survey Chart shows, as we might expect, no well defined narrow channel but a waterway varying from about 30 to over 100 feet in depth, extending almost from shore to shore between Throg's Neck (Ft. Schuyler) and College Point. Here shoals to the east of Riker's Island split the westward current which becomes further divided in its approach to the Manhattan shore, and the contracted, rocky and shallow channels through Hell Gate, Little Hell Gate and Bronx Kills cause an increase in slope and velocity of the water surface at times of the strength of tide.

We may, however, draw the following inferences from an inspection of the data secured.

1. The beginning of the ebb current occurs about two hours later than at Governor's Island. According to the observations it begins earlier at Throg's Neck than at Hallet's Point, being 2 hrs. 15 mins. after H. W. G. I. between Sanford's Point and Riker's Island, 2 hrs. 45 min. off Whitestone Point, 1 hr. 50 min. near Thorg's Neck and about one hour one half mile N. E. of Throg's Neck.

2. The mean velocity is probably about 1.2 miles per hour for a full tide but this varies with the location.

3. The maximum velocity varies yet more with the characteristics of the channel. On the flood, 4.0 miles per hour was noted just east of Little Hell Gate and 3.6 mi. per hr. north of Riker's Island, while to the east of this two miles per hour appears to be a more nearly correct figure.

On the ebb 5.0 miles per hour was found in the narrows channel east of Ward's Island, and 2.18 mi. per hr. was noted west of Riker's Island, but east of this the maximum observed velocity—between Whitestone Point and Tallman Island—was only 1.37 mi. per hr.

4. The record of float No. 25, which was set adrift 2 h. 15 m. after H. W. G. I. and taken out 1 h. 43 m. after L. W. G. I. practically comprises a complete ebb tide. The distance traversed was 6.85 miles.

* Not observed. ** 1 h. 45 m. for Float No. 14.

Float No. 18, which was observed from 3 hrs. 7 m. after H. W. G. I. to the time of the tide at 1 hr. 43 m. after L. W. G. I. is the longest flood record, covering 4.41 miles.

Considering these two records only, the mean velocity during the ebb is 1.2 mi. per hour or 33½% greater than the 0.9 mi. per hr. noted during the flood, while the maximum velocity of 2.08 miles on the ebb exceeds the 1.98 observed on the flood by 5%. These figures mean little, however, owing to the irregular character of the currents, as already explained, but confirm in a slight degree the general opinion that there is an excess of flow from the sound into and down the East River.

5 Aside from the data contained in the foregoing table the paths taken by floats Nos. 2, 6 and 9 west of Randall's and Ward's Islands show the general trend of the currents at certain stages of the tide in this vicinity, where the current of the Harlem joins those of the eastern and southern reaches of the East River.

Float No. 2 was set adrift west of Little Hell Gate 44 minutes before H. W. G. I. and in 26 minutes traversed about 350 ft. toward the entrance to Little Hell Gate. At this period of the tide the Harlem River above Bronx Kills and the East River at Hallet's Point were presumably both in ebb, and the float would have passed Ward's Island on the north and east and thence gone down the East River.

About a quarter of an hour before H. W. G. I. the float was set adrift a little north of the previous point, and in 11 minutes traversed 300 ft. in a southerly direction, and if left would have continued down the East River west of Ward's Island or else by way of Little Hell Gate until the turn of the tide.

A quarter of an hour after H. W. G. I. it was again set out on the west side of the river west of the House of Refuge on Randall's Island, and, after curving to the south and east, at about 35 minutes after H. W. G. I., began moving to the north. Again at about 1 hr. 50 m. after H. W. G. I., when near 700 ft. from its starting point, its motion was reversed and in an hour and 40 minutes had passed its previous most southerly point. The ebb or northerly flow probably began in the Harlem a short distance north of this 20 or 30 minutes before the last reversal of float's motion. It appears, therefore, that the tidal currents of the Harlem and lower East River meet in the vicinity of Randall's Island.

6 Float No. 6 was set adrift at various points above and west of Randall's Island between 3 hrs. 5m. and 4 hrs. 44 m. after L. W. G. I. Both the Harlem and East River being in flood there was a marked tendency to pass to the south and then eastward through the Bronx Kills and Little Hell Gate. Set adrift a little south of Little Hell Gate and on the west side of the River the trend was northeasterly toward Little Hell Gate, which the float would have gone through on its way toward the Sound.

Float No. 9 was set adrift a little south of the entrance to Little Hell Gate about an hour before L. W. G. I., the Harlem and East River being in ebb. After going in a southerly direction for some 1,500 ft. its course was reversed at 5 minutes after L. W. G. I. Set adrift again it took a southerly direction again which was reversed at 50 minutes after L. W. G. I. The Harlem and East Rivers both being in ebb the influence of the Harlem appears to have been greater, although the northerly trend may have been influenced by a light southerly wind.

Passing to just above the entrance to Bronx Kills the float reversed its direction to the south 4 hrs. after L. W. G. I., again to the north at 5 hrs. L. W. G. I., and again to the south at 5 hrs. 50 m. after L. W. G. I. During this time the Harlem and East Rivers were in flood and the erratic motions of the float indicate the attempt of the two currents meeting here to secure a condition of equilibrium.

From a consideration of the above facts regarding these portions of the East River we may infer:

7 *a.* That sewage discharged in the deep water east of Riker's Island would not follow any well defined course but would be influenced by the existing and variable currents and winds. In many locations, especially in the bays and near the shores, deposits would be likely to occur.

b. Sewage finding its way to the shallower waters of Hell Gate, Little Hell Gate and Bronx Kills would in general be swept by the rapid tidal currents either to the Sound or to the East River.

c. Owing to the uncertain currents and low velocities in the Harlem between Hell Gate and Bronx Kills and from the fact that there is no positive and periodical current of any magnitude passing between the East River east of Hell Gate and the Harlem River, this

part of the River is not considered as favorable for the reception of large volumes of sewage. Such as may be discharged here may find its way either to the Hudson, to New York harbor or, possibly, to Long Island Sound.

Respectfully submitted,

KENNETH ALLEN,
Chief Engineer.

1 COMPLAINANTS' EXHIBIT No. 67. James D. Maher, Commissioner.

Copy.

Float Observations.

February 18, 1909.

Dr. George A. Soper, President Metropolitan Sewerage Commission, New York City.

DEAR SIR: I beg to report as follows the results of the observations of floats set adrift in the Upper Bay near the proposed outlet of the Passaic Valley sewer, which is, roughly, some 700 feet easterly from the Robbins Reef bellbuoy as scaled from a map in the last report of the Passaic Valley Sewerage Commissioners. This point is distant from:

The Battery	3.8	miles.*
Statue of Liberty	2.4	"
Bay Ridge	1.7	"
The Narrows	3.5	"
St. George ferry slip	1.0	"
Constable Hook	1.5	"

*In this discussion when the word "miles" occurs it is intended to mean "statute" and not "nautical" miles.

The following tables comprise a summary of the principal facts as regards the paths taken by 6 floats set out in 1907 and 9 in 1908.

2 From these results the following inferences may be drawn:

(1) In the vicinity of the proposed Passaic Valley sewer outlet, which will be referred to, for convenience, as Robbins Reef, the flood current is running to the west, up the Kill van Kull, at about 2 hours after L. W. G. I., (Float #28), and in a northerly direction shortly after this time (Float of March 5, 1907*) until 2 hrs. after H. W. G. I. (Float #32). A southerly (ebb) current may be expected here at other times.

(2) The extreme points reached during a single tide were, in the:

						Float No.
Kill van Kull, Shooters Island—a distance of	5.27	mi. in	4 h.	38 m...		28
Hudson River, 60th St., Manhattan— "	9.14	"	6 h.	18 m...		34
Upper Bay—E. side, Red Hook— "	2.78	"	3 h.	23 m...		35†
Lower Bay—From 2¾ mi. S. E. to— "	11.50	"	6 h.	0 m...	2/26/07	
2 mi. S. W. of West Bank Light— "	11.25	"	6 h.	30 m...	7/ 9/07	

*It is possible that this float would have been influenced more by a westerly current up the Kill van Kull if it had not been set out ¾ N. E. of Robbins Reef, and if a moderate S. W. wind had not been blowing.

†No float went up the East River. Float #35, evidently influenced by a strong west wind, might have done so if set out earlier.

3 Velocities observed near the location of the proposed outlet of the Passaic Valley sewer were as follows:

Time after H. W. G. I.	Float.	Current.	Veloc. Ft. per Sec.
1 h. 20 m.	No. 32	Flood	1.2
2 h. 30 m.	" 31	Ebb	0.6
2 h. 50 m.	3/4/07	"	2.2
3 h. 0 m.	6/25/07	"	3.7
3 h. 20 m.	No. 37	"	0.2
3 h. 40 m.	7/8/07	"	2.5
3 h. 50 m.	2/26/07	"	2.2
3 h. 50 m.	7/9/07	"	2.2
5 h. 45 m.	No. 30	"	2.8
Time after L. W. G. I.			
0 h. 40 m.	No. 29	"	2.6
2 h. 0 m.	No. 26	"	2.1
3 h. 0 m.	3/8/07	Flood	1.5
4 h. 0 m.	No. 34	"	1.9
4 h. 15 m.	No. 37	"	0.3
4 h. 30 m.	No. 35	"	0.7
5 h. 0 m.	No. 33	"	1.7

The above figures indicate velocities varying from 0.3 ft. to 1.9 ft. per sec. on flood currents and from 0.2 to 3.7 ft. per sec. on ebb currents. The low value of .2 ft. per sec. coming 3 h. 20 m. after H. W. G. I. and 0.3 with the same float 4 h. 15 m. after L. W. G. I. indicates a considerable variation in the velocities that may occur at any given time. It is evident that at times the velocity of the current would not prevent deposition of sludge, while at other
4 times a good scouring action would obtain, more particularly on the ebb, where the velocities are seen to exceed those on flood currents.

As to the mean and maximum velocities at other points the data given indicate that during flood currents:

1. A mean velocity of about 1.7 mi. per hour may obtain in Kill van Kull.

2. Mean velocities of from 0.8 to 1.45 may occur at points between Robbins Reef and the Hudson opposite 60th St.

3. A maximum velocity of 2.6 mi. per hr. may obtain in Kill van Kull.

4. Maximum velocities of from 1.5 to 1.65 may be expected at points between Robbins Reef and a point in the Hudson River 6 miles to the north (near Christopher St.)

and that during the ebb currents:

1. Mean velocities of from 1.2 to 1.9 mi. per hr. may be expected.

2. Maximum velocities will be found varying from 2 to 4.25 mi. per hour. The maximum velocities appear to increase from Robbins Reef to the Narrows, as would be expected on account of the constricted section, or possibly below, 3.14 mi. per hour being noted in the case of Float #32 nearly as far south as Hoffman Island.

The values given depend, of course, upon the location, the winds

Float No.	....	....	....	....
Date	2/26/07.	3/4/07.	3/5/07.	6/26/07.
H. W. G. I.	7.08 A. M.	11.17 A. M.	Noon.	8.38 A. M.
L. W. G. I.*††	1.24 P. M.	5.33 P. M.	5.44 A. M.	....
Current	Ebb.	Ebb.	Flood.	Ebb.
Point of Starting (approx.)	1 mi. N. E. of R. R.**††	1 mi. N. E. of R. R.	⅝ mi. N. E. of R. R.	½ mi. E. of R. R.
Time after H. W. G. I.	2 h. 52 m.	2 h. 13 m.	....	2 h. 22 m.*
" " L. W. G. I.	....	....	2 h. 16 m.	....
Miles Traversed	11.5	11	8	•••
Time consumed	6 h. 0 m.	4 h. 0 m.	6 h. 45 m.	3 h. 40 m.
Mean vel.—mi. per hr.	1.9	2.75	1.2	....
Max. " —mi. per hr.	3.0	4.25	1.5	2.0
Where max. vel. occurred	Narrows. to E. of Hoffman I.	Narrows. to E. of Swinburne I.	In Hudson 6 mi. N. of R. R.	E. of S. I. ferry to Quarantine.
Current	Flood.	Flood.	Ebb.	Flood.
Point reached at slack water	2⅝ mi. S. E. of West Bank.	1 mi. N. E. of Romer Shoal.††	Hudson R. opp. 54th St.	....
Time of slack W. after H. W. G. I.	....	....	2 h. 45 m.	....
Time of slack w. after L. W. G. I.	2 h. 36 m.	....	....	....
Miles traversed	....	....	4	....
Time consumed	....	....	3 h. 05 m.	....
Mean vel.—mi. per hr.	....	....	1.3	....
Max. vel.—mi. per hr.	....	....	1.5	....
Where max. vel. occurred	....	....	In Hudson 6½ mi. N. of R. R.	....
Point reached at slack water	....	....	....	....
Time after H. W. G. I.	....	....	....	....
Time after L. W. G. I.	....	....	....	....

* Slack water probably 2 h. 20 m. after H. W. G. I.
** " " " " 3 hrs. " "
*** Record imperfect.
† Slack water in Main Channel about 1½ miles to the
†† Tide still ebbing.
*† On flood, preceded by 0.25 mi. S. W. on ebb current
**† " " " " 0.20 " " " " "
*†† L. W. G. I. 1907. Approximate only.
**†† R. R. refers to Robbins Reef.

First Observations from Near Robbins Reef.

Data Obtained.

			28.	29.	30.	31.	32.	33.	34.	35.	37.
....	....	....	9/16/08.	9/17/08.	9/18/08.	9/22/08.	9/25/08.	9/26/08.	9/28/08.	9/29/08.	10/1/08.
6/26/07.	7/8/07.	7/10/07.	12.46 P. M.	1.46 P. M.	2.35 A. M.	6.11 A. M.	7.39 A. M.	8.06 A. M.	9.15 A. M.	9.55 A. M.	11.28 A. M.
8.38 A. M.	6.38 A. M.	7.23 A. M.	6.49 A. M.	7.39 A. M.	8.42 A. M.	12.12 P. M.	2.09 P. M.	2.14 A. M.	3.10 A. M.	3.44 A. M.	5.05 A. M.
....	12.54 P. M.	1.39 P. M.	Flood.	Ebb.	Ebb.	Ebb.	Flood.	Flood.	Flood.	Flood.	Flood.
Ebb.	Ebb.	Ebb.	700' E. of	700' E. of	700' E. of	700' E. of	700' E. of	700' E. of	700' E. of	700' E. of	700' E. of
½ mi. E.	½ mi. E.	1½ mi.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.	bellbuoy.
of R. R.	of R. R.	E. of R. R.	....	....	6 h. 39 m.	2 h. 29 m.	1 h. 11 m.	....	....	....	....
2 h. 32 m.*	3 h. 32 m.	3 h. 07 m.**	1 h. 55 m.	0 h. 36 m.	....	....	....	4 h. 56 m.	3 h. 58 m.	4 h. 23 m.	3 h. 55 m.
....	....	....	5.27*†	1.85	2.19	5.21	1.0	3.33	9.14	2.78	6.85**†
ooo	6	11.25	4 h. 38 m.	1 h. 47 m.	2 h. 05 m.	4 h. 34 m.	1 h. 11 m.	3 h.44 m.	6 h. 18 m.	3 h. 23 m.	6 h. 39 m.
3 h. 49 m.	3 h. 50 m.	6 h. 39 m.	1.08	1.04	1.05	1.12	....	0.89	1.45	0.82	1.09
....	1.5	1.75	2.69	3.09	1.91	3.18	....	1.65	2.55	1.51	3.53
2.0	2.0	2.5	In Kill	.4 to .8 mi.	From start	Midstream	....	Midway betw.	From .3 mi.	From .2 mi.	Between Castle
N. of S. I.	Narrows.	Narrows	van Kull	from Rob-	to Baxter	off Sta-		Robbins Reef	E. of Ellis Id.	W. to 1.2 mi.	William &
ferry to		to E. of	opp. New	bins Reef.	Ledge An-	pleton.		& Gov's Id.	to opp. Cro-	N. E. of start-	the Aquarium.
Quarantine.		Swinburne I.	Brighton.		chor Buoy.				nunipaw.	ing point.	
			Ebb.		Flood.		Ebb.	Ebb.	Ebb.	Ebb.	Ebb.
Flood.	Flood.	Flood.	South of	Flood.	Just S. of	Flood.	1 mi. N. E.	0.6 mi.	N. J. side of	off Red	Near Pier at
....	½ mi.	2 mi. S. W.	Shooters' I.	2 mi. S.	Canal St.	South	of Robbins	N. E. of	Hudson opp.	Hook.	foot of Bank
	S. E. of	of Wets		of R. R.	Pier —	Beach.	Reef.	Liberty I.	60th St.,		St., Manhatten.
	Hoffman I.	Bank.			Stapleton.				Manhattan.		
....	....	....	0 h. 38 m.	....	1 h. 38 m.	....	2 h. 22 m.	2 h. 48 m.	4 h. 11 m.	1 h. 35 m.	3 h. 52 m.
....	1 h. 06 m.	3 h. 20 m.†	....	3 h. 16 m.	to 2 h. 21 m.	1 h. 02 m.	....	....	....	....	....
....	1.75	....	....	4.10	1.16	....	7.55	....	....	2.68	....
....	2 h. 45 m.	....	....	4 h. 50 m.	2 h. 38 m.	....	5 h. 12 m.	....	....	3 h. 38 m.	....
....	.64	....	....	0.85	.44	....	1.37	....	....	.79	....
....	....	....	....	1.58	1.05	....	3.14	....	....	1.08	....
....	....	....	....	.8 mi. E.	.7 mi. E. of	....	⅝ to ¼ mi.	....	....	From opp.	....
				of R. R.	Stapleton.		N. of			50th St. to	
							Hoffman I.			53rd St.	
										Bklyn.	
....	....	....	....	.65 mi. S.W.	....	....	⅝ mi.S. E.	....	....	....	....
				of Gov's I.			of Hoffman I.				
....	....	....	....	1 h. 59 m.	....	....	....	....	....	....	....
....	....	....	....	....	....	....	1 h. 13 m.	....	....	....	....

† W. G. I.
" "

* mile to the east.

** ebb current in 11 minutes.
" " 46 "

and the land water flow from the Hudson, any one of which may exert a marked influence on the velocity of the current.

An examination of the plotted paths of these floats show- a tendency in many cases to hug the shore—of Jersey City in the case of No. 34; of Brooklyn in the case of #35; of Manhattan in the case of No. 37; of Staten Island above the Narrows in the case of the floats of 2/26/07, 3/4/07, 7/8/07 and Nos. 29 and 32, and of Staten Island below the Narrows in the case of the float of 6/26/07 and No. 31. It is noted, also, that at the turn of the tide the path described is in nearly every case (Floats of 3/8/07 and Nos. 29, 30, 32, 33, 34 and 37) counter-clockwise, or to the left. The exceptions are in the case of floats No. 31, close to the Staten Island shore, and No. 35, which may have been influenced by a strong west wind. This phenomenon is confirmed by the statement of Mr. Jacob Walker, salinometer observer, Robbins Reef, who states that

at high water the current sets N. N. W.
at mid-ebb " " " S. E.
at low water " " " S. S. W.
at mid-flood " " " W.

It is probable that times of slack water will vary in the Hudson and Upper Bay with the volume of land water passing out but the observed times have been, in round numbers, as follows:

Float No.	Location.	Slack High Water.
34	West side of Hudson opp. 60th St.....	4 h. 10 m. after H. W. G. I.
3/ 5/07	East " " " " 54th "	2 h. 45 m. " "
37	East " " " " Bank "	3 h. 50 m. " "
33	0.6 mi. N. E. of Liberty Island.....	2 h. 50 m. " "
35	Off Red Hook.....	1 h. 35 m. " "
7/ 9/07	1¼ mi. N. E. of Robbins Reef..... ...	3 h. 00 m. " "
32	1 " " " " "	2 h. 20 m. " "
7/26/07	½ " " " " "	0 h. 20 m. " "
28	S. of Shooters Island.....	

6

Float No.	Location.	Slack Low Water.
28	½ mi. S. of Robbins Reef.....	1 h. 55 m.
37	" " " "	3 h. 55 m.
29	2 " S. E. " "	3 h. 15 m.
30	Canal St. Pier—Stapleton.....	2 h. 0 m.
31	South Beach, S. I.....	1 h. 0 m.
7/ 8/07	½ mi. S. E. of Hoffman Id.....	1 h. 05 m.
2/26/07	2¾ mi. S. E. of West Bank Light.....	2 h. 35 m.
7/ 9/07	1½ " S. " " "	3 h. 20 m.

These results, obtained from so limited a series of observations, appear so erratic that no safe conclusions can be drawn from them except to emphasize the fact the times of slack water are subject to considerable variation.

Another curious action of the floats observed is in the curve described near West Bank Light and near the end of the ebb by the float of 2/26/07 to the east with a southerly wind and by that of 3/4/07 to the east with a northerly wind, while the float of 7/9/07 describes a curve toward the west in spite of a westerly wind.

(Here follows paster, marked page 7.)

Finally it may be said, in general:

(*a*) That sewage if discharged at the proposed outfall near Robbins Reef might for short periods of the tide be carried up the Kill van Kull as far as Shooters Island but with currents that would prevent much deposition unless near the shores.

(*b*) That it might reach as far north in the Hudson as 60th St.

(*c*) That, with a strong westerly wind it might be carried
8 to Red Hook or possibly into the East River and then return along the Brooklyn shore.

(*d*) That the ebb current would carry it below the Narrows and at times as far as Romer Shoal.

(*e*) That if the bottom velocities at the outlet are similar to those near the surface, they would not at all times prevent the formation of deposits, but with fine screening and sedimentation the periodical maximum tidal currents would probably remove the greater part of such deposits.

(*f*) That there appears to be a tendency for the currents from Robbins Reef to follow the shores.

Respectfully submitted,

(Signed) KENNETH ALLEN,
Chief Engineer.

1 COMPLAINANTS' EXHIBIT No. 69. James D. Maher, Commissioner.

Copy.

Float Observations.

February 13, 1909.

Dr. George A. Soper, President Metropolitan Sewerage Commission, New York City.

DEAR SIR: I beg to supplement my report of November 19, 1908, on float observations in the East River south of Hell Gate with the following notes concerning Float No. 36 which had not been plotted at that time:

Float No. 36, September 30, 1908.

L. W. G. I. 420 A. M. H. W. G. I. 10.30 A. M

	Flood record.	Ebb record.
Start—No. mi. from N. end of Governors Id	0.65 miles	10.34 miles
Time after	LWGI—3h., 22m.	HWGI—2h., 10m.
Miles traversed	9.69 miles	4.55 miles
Time consumed	4h., 52m.	2h., 30m.
Mean vel.—mi. per hour	2.09	1.82
Max. " " " "	4.30	6.00
Where max. occurred—mi. from N. end of Governors Is	5.0	6.7
Beginning of Ebb current—Time after HWGI*	.....	2h., 10m.
Mi. from N. end of Governors Id	.....	10.65

*After 14 minutes of slack water.

2 Comparing these figures with those deduced from the floats considered in my reports of Nov. 19* and (with reference to the time of slack high water) of Nov. 9*, the conclusions then reached appear to be confirmed except that the maximum velocities noted with float No. 36 are somewhat less than with those previously noted: 4.3 in place of 6.8 in the case of flood currents and 6.0 in place of 9.0 mi. per hr. (9.0 to 6.0 being given as the probable range). I do not attach great importance to this variation; 1st, because the records are too few in number to draw definite conclusions as to the maximum velocity; 2nd, because the records of float No. 36 cover but a part of a tide—about 5 hrs. of the flood and 2½ hrs. of the ebb; 3rd, because the maximum velocity depends on the

*See page 2 of that report.

relation of tidal levels as affected by the winds in the bay and in Long Island Sound; and 4th, because it depends on the cross-section of the stream, which varies greatly in this stream:

Float No. 36 traversed 9.69 miles in 4 h. 52 m. of flood and 4.53 miles in 2 h. 30 m. of ebb. This is the longest flood record in the lower East River and it is noted that the longest ebb record (Float No. 10) covered 9.7 miles in 4 h. 30 m., the mean velocity being 2.16 mi. per hour, while on the flood float No. 36 made an average of 2.09 mi. per hr., indicating no great preponderance of flow in either direction.

The record of float No. 36 confirms the opinion that the trend of westerly currents through Hell Gate is down the westerly side of Blackwell's Island, and show that the flood current may also tend
to pass through this channel, although (Float No. 38) this
3 is not always the case.

The duration of slack water south of North Brother's Island was 14 minutes.

The tendency of the flood current to hug the Brooklyn shore is confirmed. In this case, in spite of a "moderate" to "strong" northeast wind, the float drifted into three slips between Wallabout Bay and Newtown Creek and had to be re-set.

Respectfully submitted,

(Signed) KENNETH ALLEN,
Chief Engineer.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

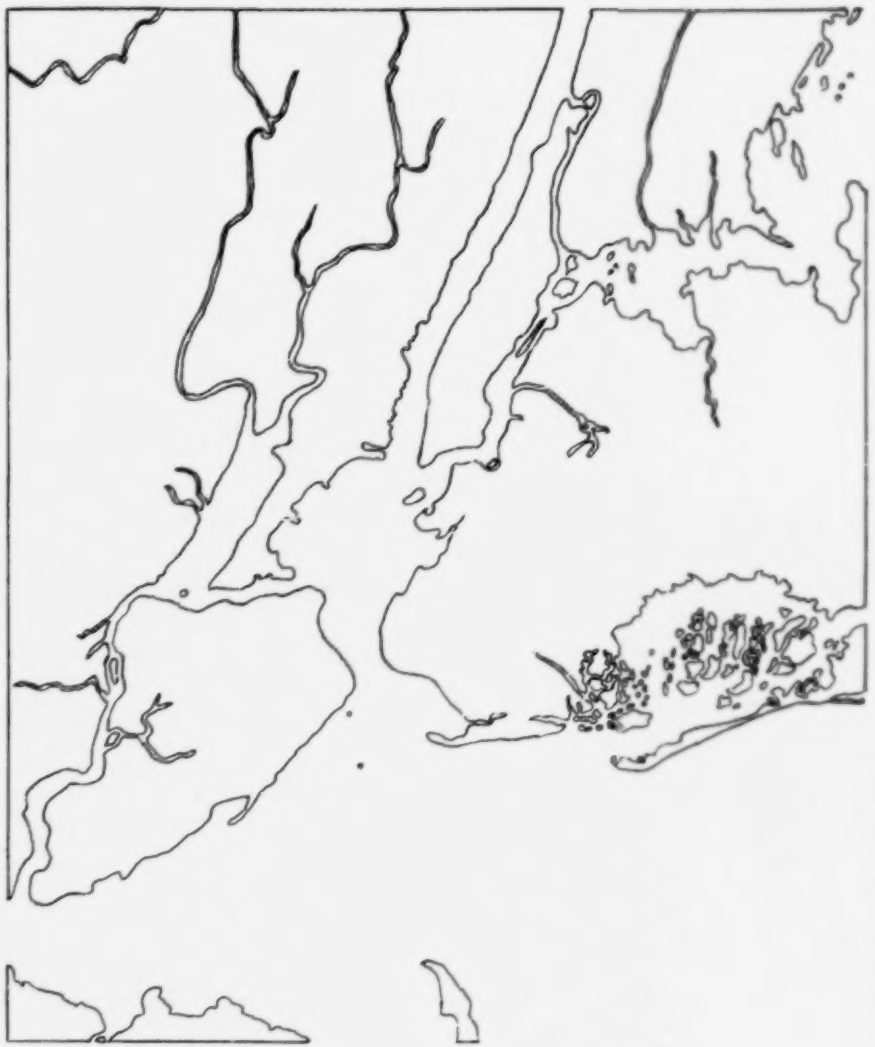
VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 88.

JAMES D. MAHER,
Commissioner.

The Harbor of New



at Mean Low Water



at 6 feet below M.L.W.

Compensations
James D.

ARBOR OF NEW YORK

SCALE
Statute Miles
0 5 10 15



6 feet below M.L.W.



at 12 feet below M.L.W.

Compromise Exhibit No 88

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBITS Nos. 89 and 90.

JAMES D. MAHER,
Commissioner.

Figure 34 Complainants Exhibit No. 89 James Gerdner Commissioner

Surface Current Movements during Successive Tides through the HUDSON RIVER, UPPER and LOWER N.Y. BAYS

Calculated from Velocities given in Tide Tables for 1918

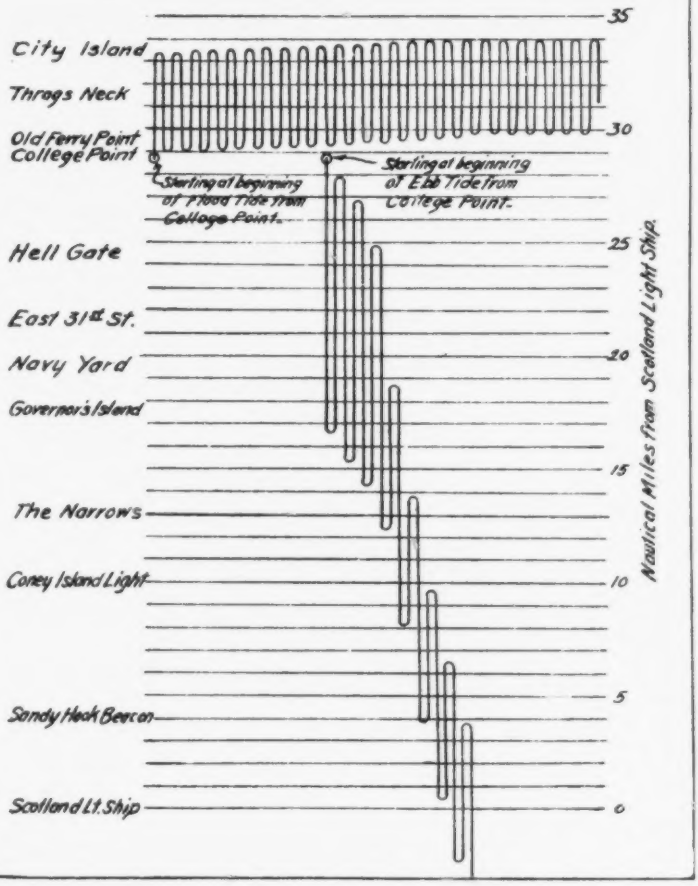




Figure 33 Complainants Exhibit No. 90 James Dunphy Engr.

Surface Current Movements during Successive Tides through the EAST RIVER, UPPER and LOWER N.Y. BAYS

Calculated from Velocities given in Tide Tables for 1908.



Complainant's Exhibit No. 91.
James Dingman
Commissioner

BRIEF REPORT ON THE TIDAL ACTIONS

IN THE HARBOR OF NEW YORK

by

H. de B. Parsons.

18th December, 1911.

H. DE B. PARSONS,
71 WILLIAM STREET,
NEW YORK

BRIEF REPORT ON THE TIDAL ACTIONS
IN THE HARBOR OF NEW YORK
by
H. de B. Parsons.

It is difficult to clearly and concisely describe the tidal actions of the water in the Harbor of New York, because the movements of the water are not synchronous in all parts of the harbor. The salient features, however, are contained in this report.

TABLE 1.

Areas, Depths, Tidal Ranges, Volumes and Tidal Prisms.

	Area Sq.M.	Av. Depth ft.	Av. Tide Range ft.	Volume below M.L.W. cu.ft. ∮	Tidal Prism cu.ft. ∮	Per-centage. H
Upper Bay	20.74	22.4	4.4	12,970	2,541	19.6
Hudson River, Battery to Wt.St.Vincent	14.49	30.7	4.2	12,330	1,697	13.7
East River, Battery to East 88th Street	3.50	31.7	4.7	3,091	459	14.8
East River, East 88th St. to Old Ferry Pt.	9.12	22.3	6.2	5,680	1,575	27.7
East River, Old Ferry Pt. to Throg's Neck	2.58	38.8	7.1	2,791	511	18.3
Harlem River	0.70	9.7	5.3	189	103.4	54.7
Newark Bay	8.35	6.6	4.6	1,542	1,071	69.3
Kill van Kull	1.12	23.4	4.8	728	149.8	20.6
Arthur Kill	4.63	13.1	5.4	1,690	697	41.2

∮ In Millions of cubic feet.

H Ratio of tidal prism to volumes below M.L.W. in per cent.

TABLE

Normal Swiftest Surface Velocities at Strength in Knots, and Normal Duration of Surface Currents in Lunar Hours.

	Velocity at Strength		Duration Lunar Hours	
	Ebb	Flood.	Ebb	Flood.
The Narrows	2.1	1.8	6.7	5.3
Hudson River, off 39th Street	3.0	2.0	6.7	5.3
East River, Brooklyn Bridge	3.8	3.6	6.6	5.4
off 11th Street	3.0	2.9	6.1	5.9
" 31st Street	2.9	2.6	6.0	6.0
at Hell Gate	4.8	4.7	6.9	6.1
off Old Ferry Point	1.3	1.3	5.8	6.2
Kill van Kull, off Port Richmond	2.2	1.9	6.3	5.7
0.1 mile S. of Bergen Point	2.0	1.8	6.4	5.6
Harlem River, off 114th Street	1.0	1.0	5.9	6.1
600 ft. N. of High Bridge	1.9	1.8	6.0	6.0

The durations of slack-water are not the same in all parts of the harbor, nor does the current change at the same time in all parts of a section. The slack-water periods are included in the duration of the currents which add to 12 lunar hours.

CURRENTS AT EACH LUNAR HOUR.

The currents which exist in the harbor at each lunar hour of a tidal cycle are given below. The directions of the currents were chiefly obtained from the float experiments of the Metropolitan Sewerage Commission and from curves given on Figure Other observations were also made for purposes of verification.

One lunar hour equals 1.03508 solar hours.

At Governer's Island, high-water occurs 6 hours and 4 minutes (solar) after transit of moon. Low-water, 2 hours and 9 minutes (solar) after transit.

I Lunar Hour. The water is flowing out of the Upper Bay through the Narrows, toward the sea; into the Upper Bay through the Kill van Kull, the East River and the Hudson River; and the water level in the Upper Bay is falling.

II Lunar Hour. The water is flowing out of the Upper Bay, through the Narrows, toward the Sea; flowing into the Upper Bay through the East River and the Hudson River; the Kill van Kull is nearly slack; and the water in the Upper Bay at about mean low-water.

III Lunar Hour. The water is flowing out of the Upper Bay, through the Narrows toward the sea; out of the Upper Bay through the Kill van Kull, flowing into the Upper Bay through the East River and the Hudson River; and the water in the Upper Bay is rising.

IV Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea; into the Upper Bay from the Hudson River; out of the Upper Bay and Hudson River into the East River; out of the Upper Bay into the Kill van Kull; and the water in the Bay is rising.

V Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea; the Hudson River is nearly slack; flowing out of the Upper Bay through the East River and the Kill van Kull; and the water in the Bay is rising.

VI Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea; flowing out of the Upper Bay through the Hudson River, East River and Kill van Kull, and the water in the Bay is rising.

VII Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea; flowing out of the Upper Bay through the Hudson River, East River, and Kill van Kull; and the water in the Bay is rising.

VIII Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea; flowing out of the Upper Bay through the East River and the Hudson River; the Kill van Kull is nearly slack; and the water in the Bay is at about mean high water.

IX Lunar Hour. The water is flowing into the Upper Bay, through the Narrows, from the sea, and through the Kill van Kull; flowing out of the Upper Bay through the Hudson River and the East River; and the water in the Bay is falling.

I Lunar Hour. The water is flowing out of the Upper Bay, through the Narrows, toward the sea; out of the Upper Bay, and the East River through the Hudson River; into the Upper Bay and Hudson River through the East River; into the Upper Bay through the Kill van Kull; and the water in the Bay is falling.

II Lunar Hour. The water is flowing out of the Upper Bay, through the Narrows, toward the sea; the Hudson River is nearly slack; flowing into the Upper Bay through the East River and the Kill van Kull; and the water in the Bay is falling.

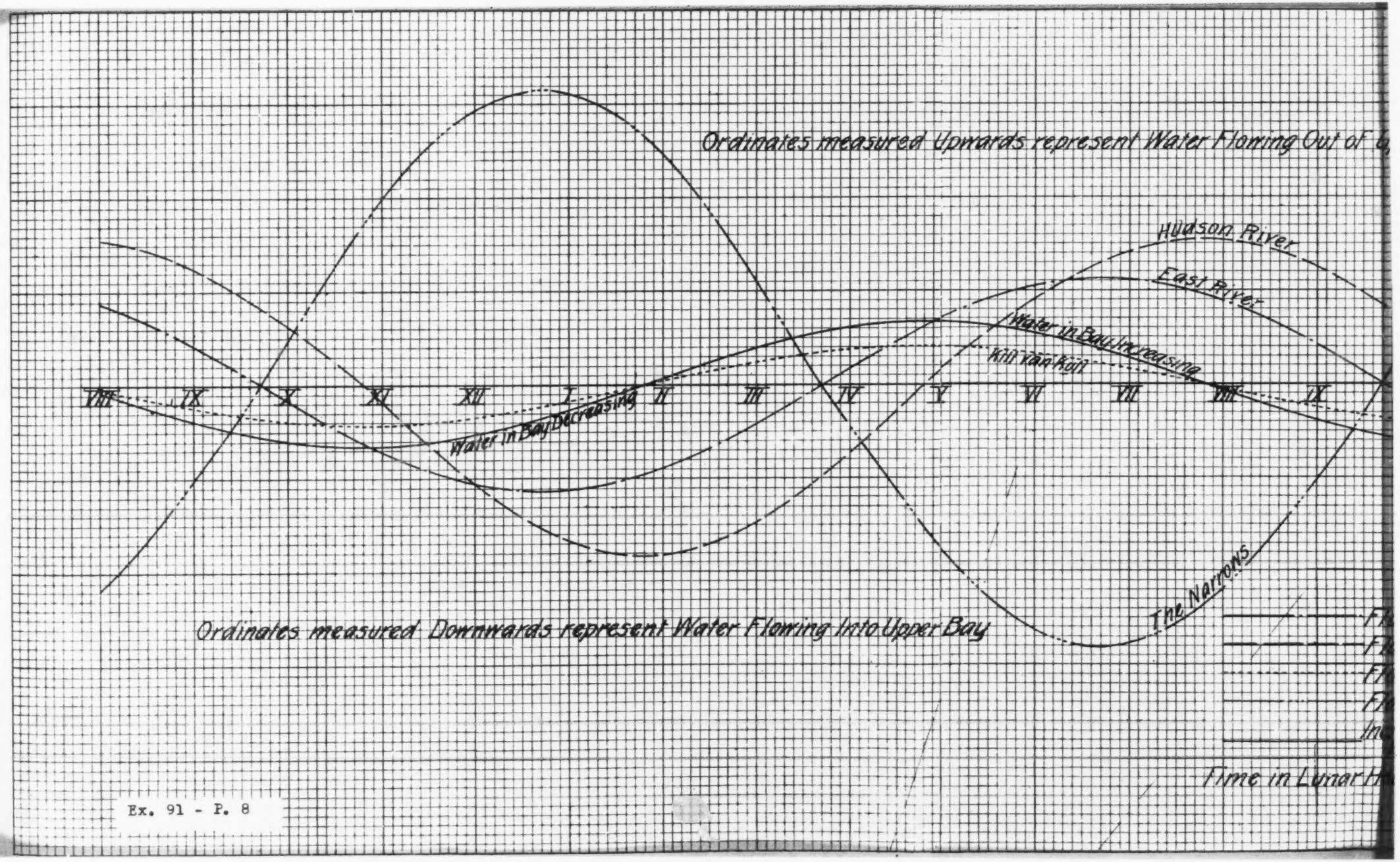
III Lunar Hour. The water is flowing out of the Upper Bay, through the Narrows, toward the sea; into the Upper Bay through the Hudson River, East River and Kill van Kull; and the water in the Bay is falling.

Tidal Volumes in Cubic Feet
Estimates of Volumes of Ebb and Flood Currents
Harbor of New York

Reference	The Narrows between Fort Hamilton & Hamilton	Hudson River off 39th St. Manhattan	East River off Brooklyn Bridge	East River off E. 11th St. Manhattan	East River off E. 31st St. Manhattan	East River off E. 81st St. Manhattan	East River off Old Ferry Point	The Kill van Kull off Port Richmond	The Kill van Kull between Constable Point & Near Brighton	Harlem River off 145th St. Manhattan	Harlem River Section 600' North of High Bridge
1 Width of section in feet	5,280	3,900	1,500	2,235	3,180		3,080	1,380		460	410
2 Average depth below M.W. level feet	61.0	37.44	44.20	36.13	39.07		43.88	28.30		15.67	11.71
3 Area of Section, square feet	322,000	146,000	66,300	80,750	124,250		131,650	39,060	35,475	7,210	4,800
4 Avg Velocity (surface) in feet per second Ebb, Kc	1.38	1.86	2.42	1.91	1.13		0.88	1.48		0.71	1.30
5 " " " " " Flood, Kc	1.17	1.26	2.22	1.85	1.29		1.09	1.24		0.69	1.22
6 " " " " " Mean Kc	1.255	1.56	2.32	1.88	1.21		0.985	1.36		0.70	1.26
7 " " " " " Mean parabolic	7,631	9,485	14,105	11,430	7,357		5,989	8,269		4,256	7,661
8 Coef (product of (7)) to cross sectional area	0.75	0.75	0.75	0.75	0.75		0.75	0.75		0.75	0.75
9 Mean cross sectional area in feet per solar hour	5,723	7,113	10,504	8,572	5,518		4,491	6,202		3,192	5,746
10 Mean rate of flow through section in cubic feet per solar hour in millions, (3) x (9)	1,837	1,038	696.5	692.2	685.6		591.3	242.2		23.01	27.58
11 Number of solar hours in 6 hour tides	6.21	6.21	6.21	6.21	6.21		6.21	6.21		6.21	6.21
12 Mean volume flowing on ebb and flood currents in millions of cubic feet, (10) x (11)	11,410	6,447	4,330	4,299	4,258	3,930	3,672	1,502	1,600	142.9	171.2
13 Mean yearly discharge of land water from Ebb area having mean velocity of	591.2	543.6						44.1	44.1	ditto (12) prorate to average areas during Current equals	ditto
and equivalent from East River 80 M. cu ft.	80.		80	80	80	80	80				
	671.2										
Average Volume flowing through section in millions cubic feet per tide											
14 On Ebb	12,041.2	6,990.6	4,370	4,339	4,298	3,970	3,712	1,546.1	1,644.1	151.8	179.8
15 On Flood	10,778.8	5,903.4	4,290	4,259	4,218	3,890	3,632	1,457.9	1,555.9	134.0	162.6

U.S.C. & G. Survey Letter of 14th August 1908

U.S.C. & G. Survey Letter of 14th August 1908


Ordinates measured Upwards represent Water Flowing Out of
Hudson River
East River
Water in Bay Increasing
Kill van Kull
VIII IX X XI XII I II III IV V VI VII VIII IX
Water in Bay Decreasing
The Narrows
Ordinates measured Downwards represent Water Flowing Into Upper Bay
Time in Lunar

Ex. 91 - P. 8

Ordinates measured Upwards represent Water Flowing Out of Upper Bay

Hudson River

East River

Water in Bay Increasing

Kill van Kull

X XI XII I II III IV V VI VII VIII IX X XI XII

Water in Bay Decreasing

The Narrows

3,000 2,000 1,000 0 1,000 2,000 3,000

Flow in Millions of Cubic Feet per Lunar Hour

Ordinates measured Downwards represent Water Flowing Into Upper Bay

Flow of East River

Flow of Hudson River

Flow of Kill van Kull

Flow of The Narrows

Increase or Decrease of Water in Upper Bay

Time in Lunar Hours

TIDAL VOLUMES.

Estimates of the volumes flowing on the tides past various sections of the harbor were made, chiefly based on investigations of the Metropolitan Sewerage Commission. These estimates agree with those of the U. S. Coast and Geodetic Survey.

Average Volumes in Million Cubic Feet.

	Ebb.	Flood.	Resultant.
The Narrows	12,041.2	10,778.8	1,262.4
Hudson River, West 39th Street	6,990.6	5,903.4	1,087.2
East River, Brooklyn Bridge	4,370.0	4,290.0	80.0
Kill van Kull, New Brighton	1,644.1	1,555.9	88.2

Ex. 91 - P. 6

(Here follows sheets of Tidal Volumes in Cubic Feet, marked Ex. 91, pp. 7 and 8.)

The quantity of "new" sea-water entering Upper Bay is:-

		In million cu.ft. per tidal cycle
At the Narrows -	Average for year	2,210
	Least amount (February)	670
	Least amount (Summer-August)	1,520

These figures were determined from daily observations by the salinometer, the records covering a period of over one year as made by the Metropolitan Sewerage Commission. The average of these observations is appended.

If no land-water entered the harbors then the water in the harbor would be as salty as that of the sea. The mean quantity of water flowing on ebb tide was divided into land and sea-water by means of the salinometer percentages. The land-water was then divided into "land-water which will return" and "land-water which will not return". The latter was taken as the run-off of the rivers for 12 lunar hours and the former as the remainder of the total land-water as shown by the salinometer.

The sea-water as shown by the salinometer was then divided by making the "sea-water which will not return" the same proportion of the total sea-water as the "land-water which will not return" is to the total land-water. This is so because the land and sea-waters are mixed, and the amount of "land-water which will not return" will take with it its proportionate amount of sea-water.

The division of water on flood tide was made by taking the total volume of flow on flood and laying off the amounts of land and sea-water which will return as shown on ebb. The remainder is the "new" sea-water, or the water which was not in the harbor on the preceeding tide. It must be equal to the "sea-water which will not return" as given on ebb.

The land-water as shown by the salinometer is always in excess of the run-off. This is so because the flushing action of the harbor is not complete, as at the end of every ebb tide there remains some land-water in the harbor. The amount remaining, which is the amount in excess of the run-off, is variable, due to the seasonal variations.

The amount of "sea and land-water which will not return" is not a large proportion of the amount of water flowing on an ebb tide. There is always a large amount of "water which will return" on the succeeding flood tide.

The amount of new sea-water is never a large proportion of the total amount flowing on a flood tide. This "new sea-water" is only new off places situated near the ocean and not new at such places as the Upper Bay, Hudson River, East River, or Newark Bay. At these places the "new sea-water" is really water which has not been at the place on a previous tide, but which comes from some other part of the harbor.

The water which causes the seaward trend is the amount of land-water flowing from the water-sheds above. For places near the ocean, this seaward trend is increased by some "sea-water which will not return;" but for places situated well within the harbor such "sea-water which will not return" is replaced by sea-water as explained above, which comes from some other part of the harbor and is not clean ocean water.

The "sea-water which will return" is always greatest during the summer months and is least during the spring months.

The "sea and land-water which will not return" is least during February and the summer months, and greatest during the spring and autumn months.

Ex. 91 - P. 10

(Here follows chart showing Summary of Salinometer Records, marked Ex. 91, p. 11.)

Percentages of Land Water at the Surface.
Corrected for Temperature 60°

	1909.																														
	Jan.			Feb.			Mar.			Apr.			May.			June			July			Aug.			Sept.			Oct.			Nov.			Dec.			Averages for year.		
	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In	All	Out	In
Ambrose Channel	4.3			6.5			10.2			10.8			15.6			13.0			6.9			7.2			6.8			6.0			4.6			4.6			7.6		
West Bank	12.3	12.7	12.3	34.2	35.9	33.4	36.0	34.5	34.7	42.1	44.3	45.6	42.2	41.7	41.6	27.8	28.5	27.3	17.3	17.1	17.5	18.4	17.6	17.4	16.7	14.6	14.0	15.7	15.4	16.0	15.2	14.7	13.7	12.5	12.4	12.9	25.2	24.8	24.1
Ft. Wadsworth	29.0	28.2	30.0	50.1	50.8	52.4	50.6	49.9	51.0	64.9	69.8	67.9	59.1	56.0	61.0	38.4	38.0	37.1	25.5	24.9	28.2	23.5	28.7	30.2	28.3	24.8	32.3	22.2	21.5	25.6	22.7	22.2	23.0	25.3	23.6	27.3	37.2	34.8	37.6
Robbins Reef	24.9	23.3	24.6	42.6	41.8	42.8	43.2	43.3	44.4	56.1	55.6	55.8	62.9	62.5	57.6	34.0	33.6	33.8	21.5	21.1	21.6	21.4	21.6	21.3	18.3	18.3	18.6	19.6	19.3	20.4	13.7	13.7	13.5	22.3	21.3	22.8	31.2	30.4	30.4
Governors Is.	30.9	29.4	33.1	40.5	39.0	43.4	49.3	49.1	49.9	64.0	64.1	67.2	63.1	56.6	61.0	39.5	38.7	38.7	25.3	24.6	27.5	24.9	23.8	26.0	22.2	19.7	24.9	24.7	22.8	27.0	25.1	24.1	26.4	30.0	28.1	32.5	36.4	34.6	37.0
Blackwells Is.	26.8	26.6	26.1	35.9	36.9	34.6	37.8	39.0	37.6	45.6	45.3	44.9	47.3	41.7	42.9	33.7	34.0	33.4	27.7	26.8	28.2	25.6	26.5	24.4	24.1	24.3	23.8	25.6	25.2	26.2	24.2	24.5	23.8	25.7	25.6	25.8	31.9	31.9	31.9
Great Beds	31.7	33.1	29.2	47.1	49.5	44.1	46.5	48.6	44.6	58.2	63.4	61.0	63.6	55.5	60.3	37.6	38.9	36.1	28.7	29.3	29.0	29.6	31.4	27.1	24.2	26.4	25.9	28.9	28.6	29.0	28.9	29.0	29.7	29.6	29.2	29.9	36.8	37.2	34.6
Passaic Light	65.8	63.8	67.3	82.2	81.0	84.0	83.4	83.6	83.3	90.6	90.3	90.7	86.3	85.7	86.8	67.2	66.3	67.8	51.0	50.0	51.8	52.6	52.2	53.6	47.8	47.3	48.3	46.4	46.2	46.1	45.3	46.6	45.8	57.6	56.0	57.0	64.2	63.8	64.7
Ft. Washington Pt.	62.2	60.7	63.2	83.3	83.2	83.7	84.0	83.3	84.0	94.7	94.7	95.1	90.6	90.7	90.5	74.5	74.6	74.7	54.0	54.0	55.7	51.8	52.4	50.6	48.8	43.0	48.3	50.4	49.5	50.8	47.4	47.7	48.4	53.7	53.0	54.1	66.3	66.3	65.1
Tarrytown	84.6	84.8	84.5	91.2	91.4	91.0	98.6	98.6	98.7	100.0	100.0	100.0	99.9	99.8	99.9	93.1	93.4	92.8	80.2	80.4	80.0	74.4	75.2	73.7	73.0	73.5	72.6	73.8	74.4	73.4	73.4	73.5	73.3	76.4	76.5	76.9	85.3	85.7	84.9
Throgs Neck	15.9	15.8	16.0	19.9	19.8	18.7	20.8	21.2	20.1	23.8	23.5	24.2	24.9	24.0	24.5	21.9	21.4	21.2	18.1	18.2	18.0	17.3	17.7	17.0	17.1	16.9	17.4	15.5	15.0	15.9	13.2	13.3	13.2	11.6	11.4	11.7	18.1	18.2	18.1
RAINFALL, Percent above or below normal	-6%			+32%			-23%			+61%			-36%			+13%			-53%			+14%			-11%			-74%			-47%			+9%			-12%		

Ex. 91 - P. 11

Throgs Neck: West currents - In.

• Average of Precipitation at Albany, Carmel, New York City, Wappingers Falls and West Point, from Climatological Report, U.S. Weather Bureau.

'All' means average of Ebb, Flood and Slack Water observations.

'Out' - - - Ebb observations.

'In' - - - Flood observations.

TABLE

The Narrows.

Division of Sea and Land Water in Ebb Current by Months.

Figures in Millions of Cubic Feet during Ebb Current §

MONTH.	Land Water		Sea Water		Total Ebb Flow.
	which will return	which will not return	which will return	which will not return	
January	2,520	880	6,400	2,240	12,040
February	3,430	690	5,250	670	12,040
March	3,510	2,500	3,530	2,510	12,040
April	4,610	2,990	2,100	1,740	12,040
May	5,400	1,340	4,250	1,050	12,040
June	5,480	1,090	3,480	1,780	12,040
July	2,230	700	6,930	2,180	12,040
August	2,840	620	7,060	1,520	12,040
September	2,280	710	6,900	2,150	12,040
October	1,600	990	5,840	3,610	12,040
November	1,760	910	6,180	3,190	12,040
December	1,770	1,070	5,730	3,470	12,040
Average for Year#	3,010	1,180	5,640	2,210	12,040

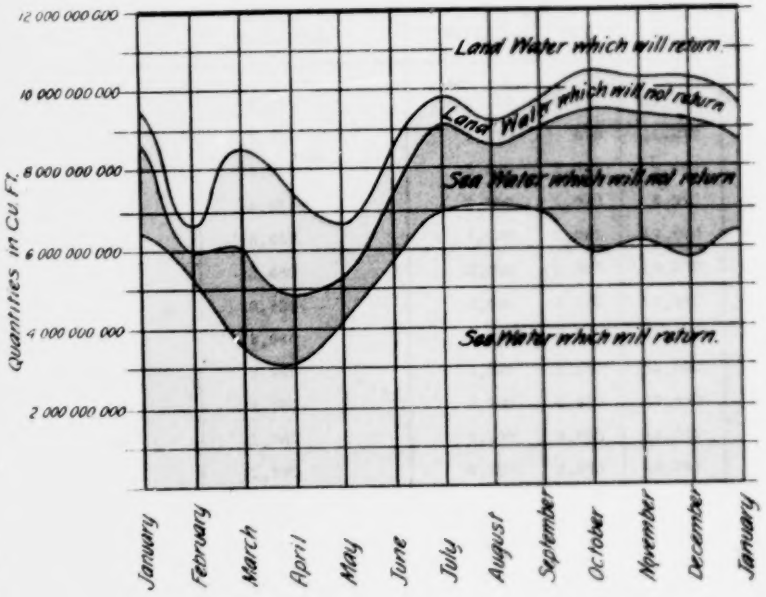
§ Shown graphically on Diagram

Average of daily readings.

Ex. 91 - P. 12

THE NARROWS
Division of Sea and Land Water by Months
from Salinometer Records made by The Metropolitan Sewerage Commission

EBB CURRENT.



Ex. 91 - P. 13

TABLE

The Narrows.

Division of Sea and Land Water in Flood Current by Months

Figures in Millions of Cubic Feet during Flood Current ∅

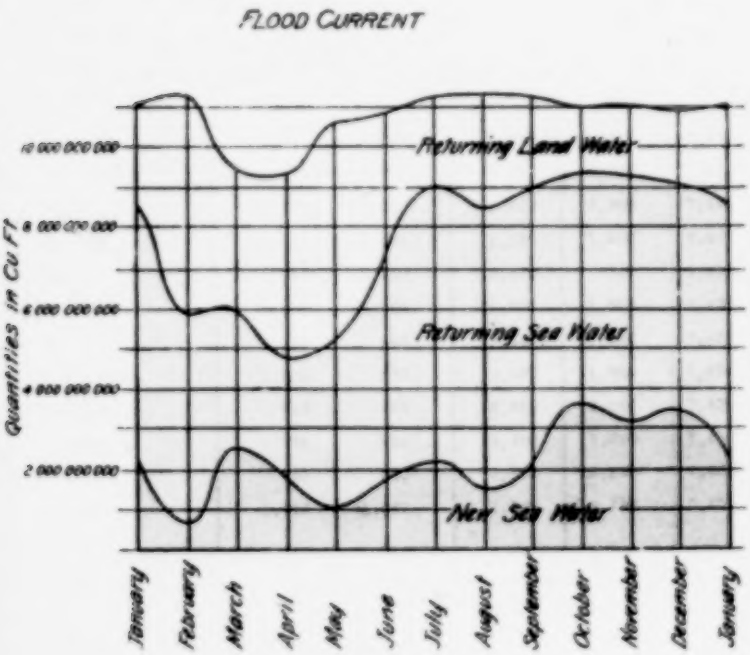
MONTH	Land Water Returning.	Sea Water		Total Flood Flow.
		Returning	New.	
January	2,320	8,320	2,240	11,080
February	5,430	5,170	670	11,270
March	3,510	3,440	2,510	9,460
April	4,610	3,020	1,740	9,370
May	5,400	4,170	1,050	10,620
June	3,480	5,610	1,780	10,870
July	2,230	6,850	2,130	11,260
August	2,840	6,980	1,520	11,340
September	2,280	6,820	2,150	11,250
October	1,600	5,760	3,610	10,970
November	1,760	6,100	3,190	11,050
December	1,770	5,650	3,470	10,890
Average for Year#	3,010	5,560	2,210	10,780

∅ Shown graphically on Diagram

\# Average of daily readings.

N These figures are 80,000,000 cubic feet less than the "Sea-water which will return" as given in Table because this is the mean resultant flow through the East River.

THE NARROWS
Division of Sea and Land Water by Months
From Salinometer Records made by The Metropolitan Sewerage Commission.



Ex. 91 - P. 15

TABLE

Hudson River, off The Battery.

Division of Sea and Land Water in Ebb Current by Months

Figures in Millions of Cubic Feet during Ebb Current ø

MONTH.	Land Water		Sea Water		Total Ebb Flow
	which will return.	which will not return.	which will return	which will not return.	
January	1,370	810	3,300	1,950	7,430
February	2,260	640	3,530	1,000	7,430
March	1,350	2,300	1,400	2,380	7,430
April	2,090	2,380	1,380	1,580	7,430
May	2,980	1,230	2,280	940	7,430
June	1,680	1,000	2,970	1,580	7,430
July	1,190	640	3,640	1,960	7,430
August	1,200	570	3,830	1,830	7,430
September	810	650	3,310	2,660	7,430
October	740	910	2,650	3,090	7,430
November	950	840	2,990	2,650	7,430
December	1,010	1,080	2,580	2,760	7,430
Average for Year#	1,480	1,090	2,800	2,060	7,430

ø Shown graphically on Diagram

Average of daily readings.

Ex. 91 - P. 16

TABLE

Hudson River, off The Battery.

Division of Sea and Land Water in Flood Current by Months

Figures in Millions of Cubic Feet during Flood Current ∮

MONTH.	Land Water Returning.	Sea Water		Total Flood Flow
		Returning.	New.	
January	1,390	3,100	1,950	6,420
February	2,860	3,530	1,000	6,790
March	1,350	1,400	3,380	5,130
April	2,090	1,380	1,980	5,050
May	2,980	2,280	940	6,200
June	1,880	2,970	1,380	6,430
July	1,190	3,640	1,960	6,790
August	1,930	3,630	1,830	6,660
September	810	3,310	2,660	6,780
October	980	2,050	3,000	6,030
November	950	2,990	2,650	6,590
December	1,010	2,580	2,760	6,350
Average for Year#	1,480	2,800	2,080	6,340

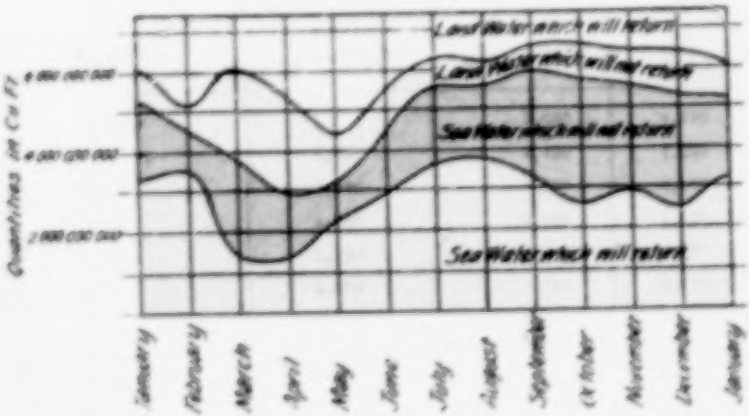
∮ Shown graphically on Diagram

Average of daily readings.

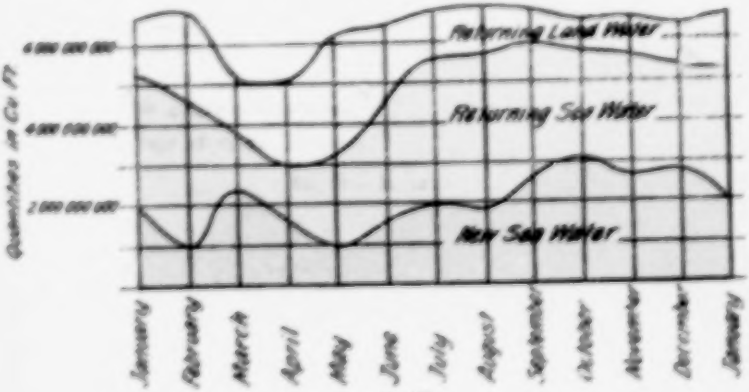
Ex. 91 - P. 17

HUDSON RIVER OFF THE BATTERY
Division of Sea and Land Water by Months
From Salinometer Records made by The Metropolitan Sewerage Commission

EBB CURRENT



FLOOD CURRENT



Ex. 91 - P. 18

TABLE

East River, off Blackwell's Island

Division of Sea and Land Water in Ebb Current by Months

Figures in Millions of Cubic Feet during Ebb Current ∅

MONTH.	Land Water.	Sea Water.	Total Ebb Flow.
January	1,100	3,050	4,150
February	1,530	2,620	4,150
March	1,580	2,570	4,150
April	1,880	2,270	4,150
May	1,730	2,420	4,150
June	1,410	2,740	4,150
July	1,110	3,040	4,150
August	1,100	3,050	4,150
September	1,010	3,140	4,150
October	1,050	3,100	4,150
November	1,020	3,130	4,150
December	1,060	3,090	4,150
Average for Year#	1,320	2,830	4,150

∅ Shown graphically on Diagram

\# Average of daily readings.

Ex. 91 - P. 19

TABLE

East River, off Blackwell's Island

Division of Sea and Land Water in Flood Current by Months

Figures in Millions of Cubic Feet during Flood Current ø

MONTH.	Land Water.	Sea Water.	Total Flood Flow.
January	1,060	3,010	4,070
February	1,410	2,660	4,070
March	1,530	2,540	4,070
April	1,830	2,240	4,070
May	1,750	2,320	4,070
June	1,360	2,710	4,070
July	1,150	2,920	4,070
August	990	3,080	4,070
September	970	3,100	4,070
October	1,070	3,000	4,070
November	970	3,100	4,070
December	1,050	3,020	4,070
Average for Year#	1,300	2,770	4,070

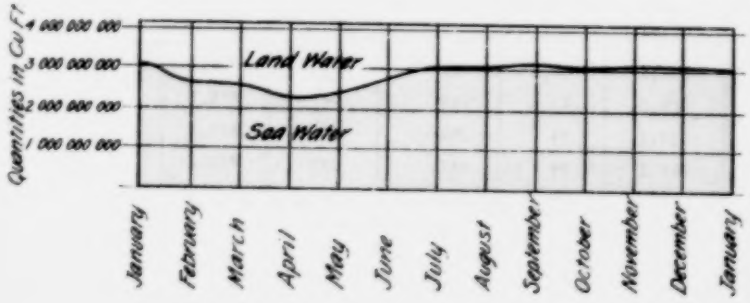
ø Shown graphically on Diagram

Average of daily readings.

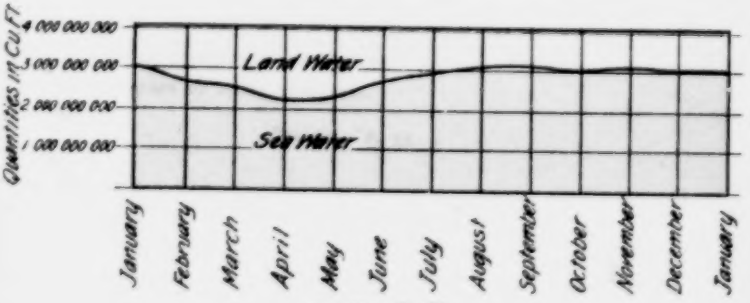
Ex. 91 - P. 20

EAST RIVER, OFF BLACKWELLS ISLAND
Division of Sea and Land Water by Months
From Salinometer Records made by The Metropolitan Sewerage Commission

EBB CURRENT



FLOOD CURRENT



Ex. 91 - P. 21

TABLE

NEWARK BAY.

Division of Sea and Land Water in Ebb Current by Months

Figures in Millions of Cubic Feet during Ebb Current.

MONTH.	Land Water.		Sea Water.		Total Ebb Flow.
	which will return	which will not return	which will return	which will not return	
January	1,179	79	669	45	1,972
February	1,535	62	360	15	1,972
March	1,424	223	281	44	1,972
April	1,549	231	167	25	1,972
May	1,570	120	262	20	1,972
June	1,210	97	616	49	1,972
July	924	62	924	62	1,972
August	973	56	892	51	1,972
September	870	63	959	70	1,972
October	823	88	959	102	1,972
November	799	81	992	100	1,972
December	999	105	785	83	1,972
Average for Year#	1,152	106	654	60	1,972

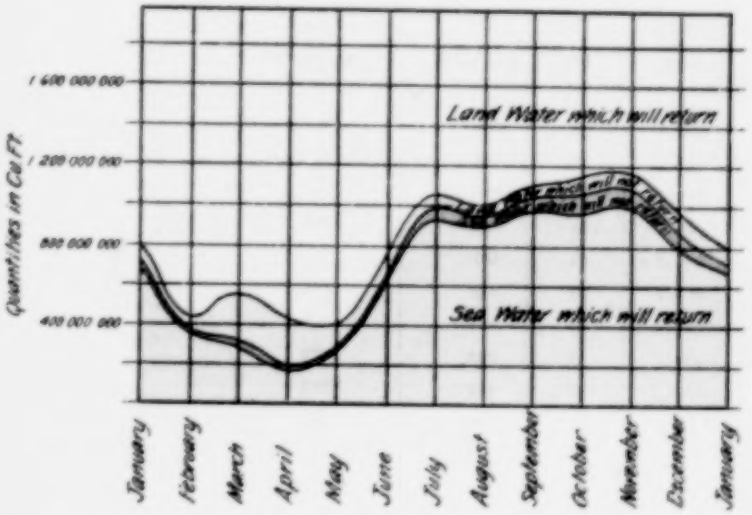
Shown graphically on Diagram

Average of daily readings.

Ex. 91 - P. 22

NEWARK BAY
Division of Sea and Land Water by Months
From Salinometer Records made by The Metropolitan Sewerage Commission

EBB CURRENT



Ex. 91 - P. 23

TABLE

Newark Bay

Division of Sea and Land Water in Flood Current by Months

Figures in Millions of Cubic Feet during Flood Current ∮

MONTH.	Land Water Returning.	Sea Water		Total Flood Flow.
		Returning.	Ret.	
January	1,179	669	45	1,893
February	1,855	360	15	1,910
March	1,424	381	44	1,749
April	1,549	187	25	1,761
May	1,570	262	20	1,852
June	1,210	616	49	1,875
July	924	924	82	1,810
August	973	892	51	1,916
September	870	969	70	1,909
October	823	959	102	1,884
November	789	992	100	1,891
December	999	905	83	1,887
Average for Year#	1,165	664	57	1,886

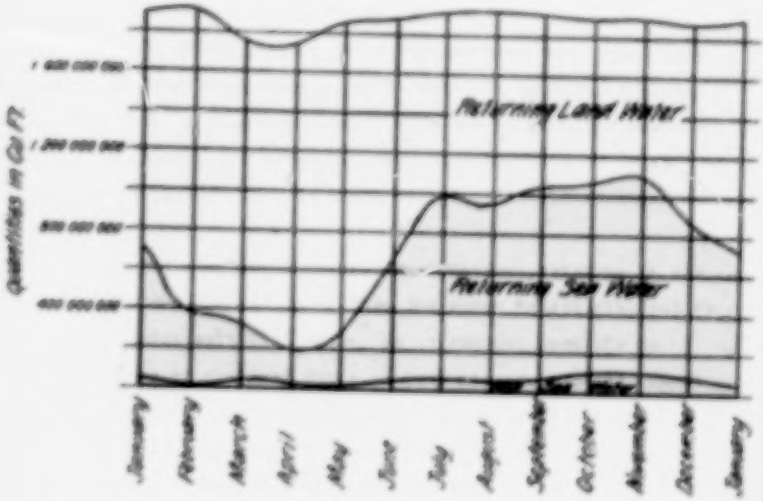
∮ Shown graphically on Diagram

Average of daily readings.

Ex. 91 - P. 84

NEWARK BAY
Division of Sea and Land Water by Morris
from Salinometer Records made by The Metropolitan Sewerage Commission

FLOOD CURRENT



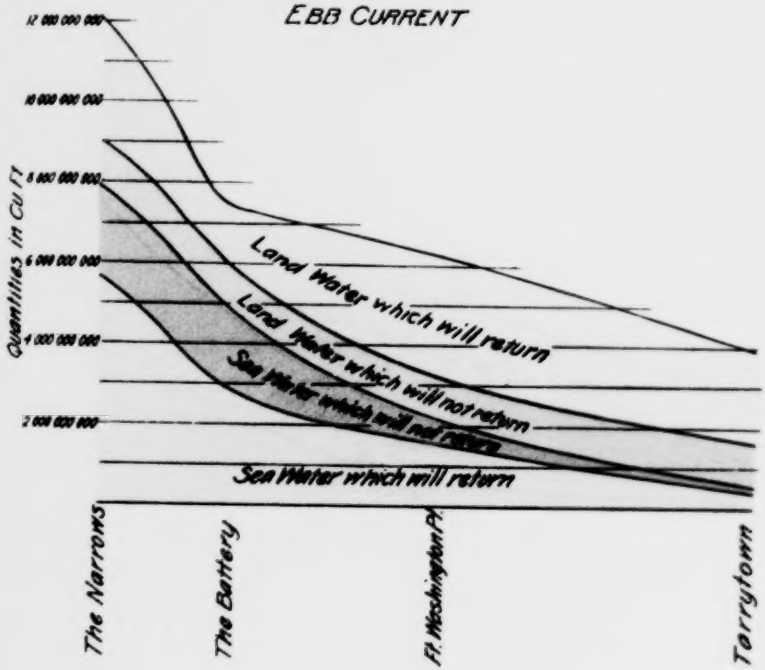
Ex. 91 - P. 25

In addition to the preceding work which shows the divisions of land-water and sea-water at various places in the harbor, the following diagrams were made to show these changes geographically. That is, the information was plotted on the diagrams by locating the distances between the different places as abscissae and the mean tidal flows in cubic feet as ordinates.

In order to show the variation from mean conditions additional diagrams were constructed to show the division of land and sea-water during August and April when the minimum and maximum amounts of land-water are flowing. This work was done by using the salinometer records for the month recorded instead of the mean record for the year.

The diagrams showing the conditions existing in the East River were not divided up to show the water "which will return" and the water which will not return", as it was not possible to divide the waters of the East River in this manner, because, first the East River is a strait, open at both ends to bodies of salt water, and secondly, because the water sheds draining into the East River were so small that if a division had been attempted the divisions of "land-water which will not return" would be so small as hardly to appear thicker than a line on the diagrams.

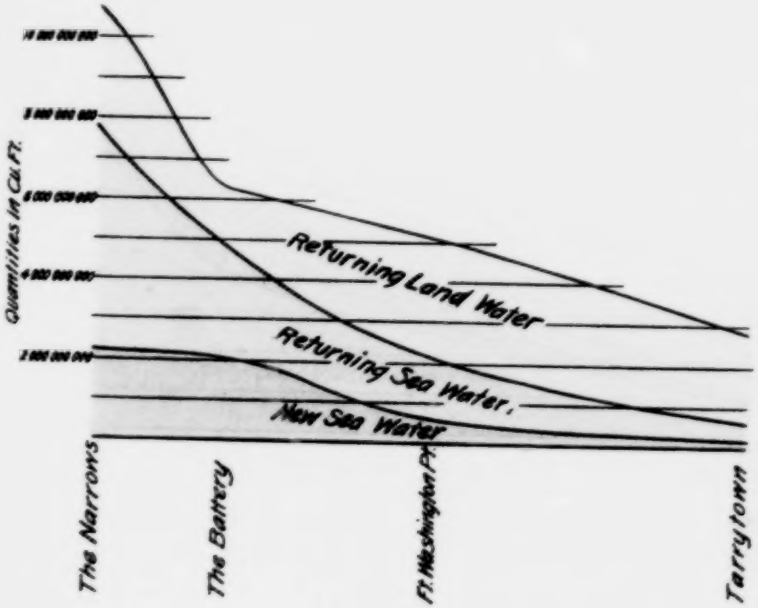
UPPER BAY AND HUDSON RIVER.
Division of Sea and Land Water
when Average Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission



Ex. 91 - P. 27

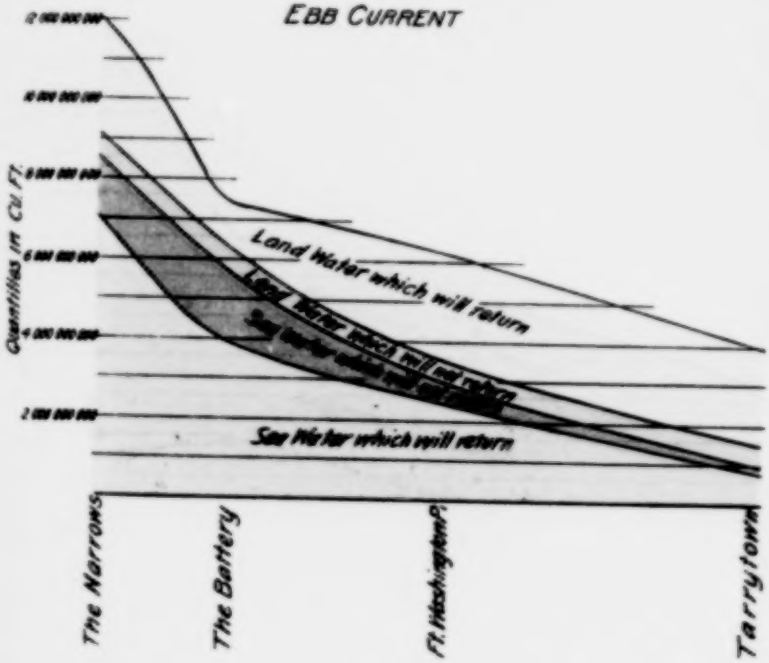
UPPER BAY AND HUDSON RIVER.
Division of Sea and Land Water
When Average Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission

FLOOD CURRENT



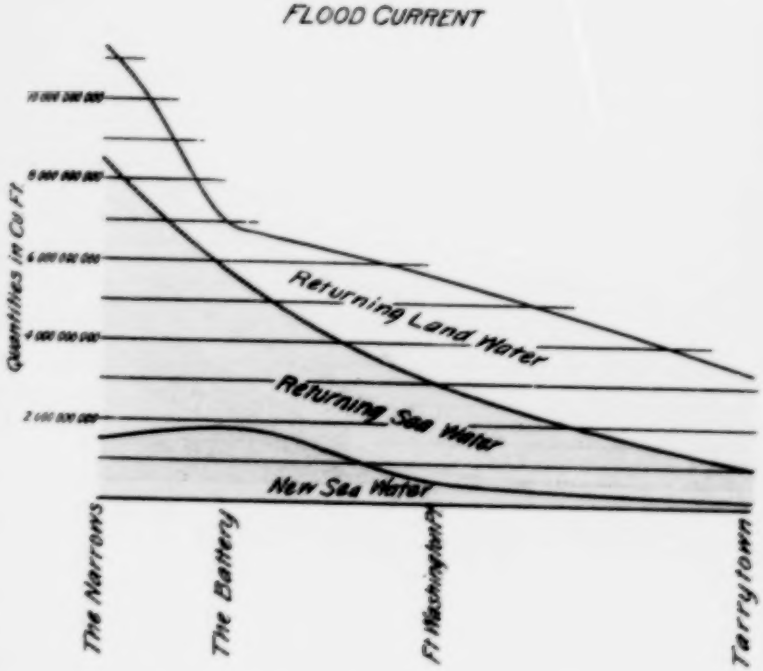
Ex. 91 - P. 28

UPPER BAY AND HUDSON RIVER
Division of Sea and Land Water
during August when Minimum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission



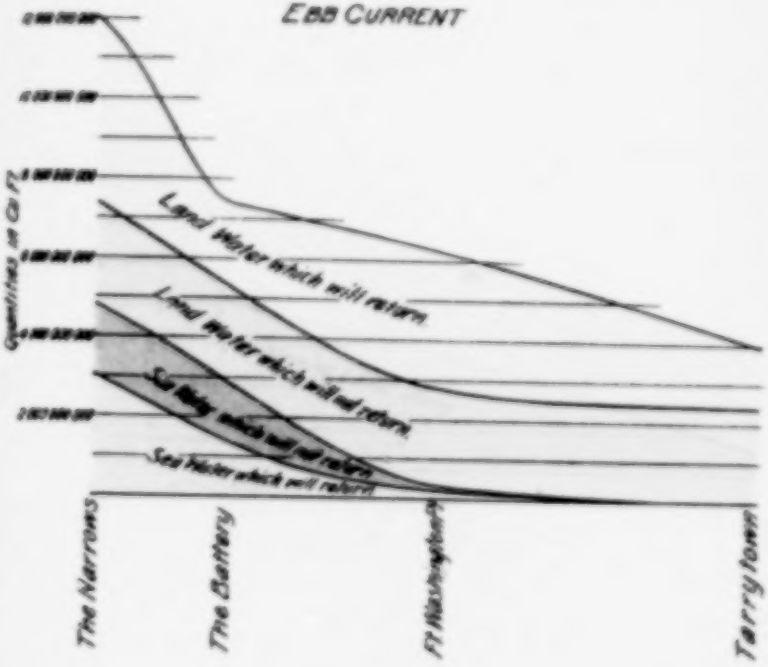
Ex. 91 - P. 29

UPPER BAY AND HUDSON RIVER.
Division of Sea and Land Water
during August when Minimum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission



Ex. 91 - P. 30

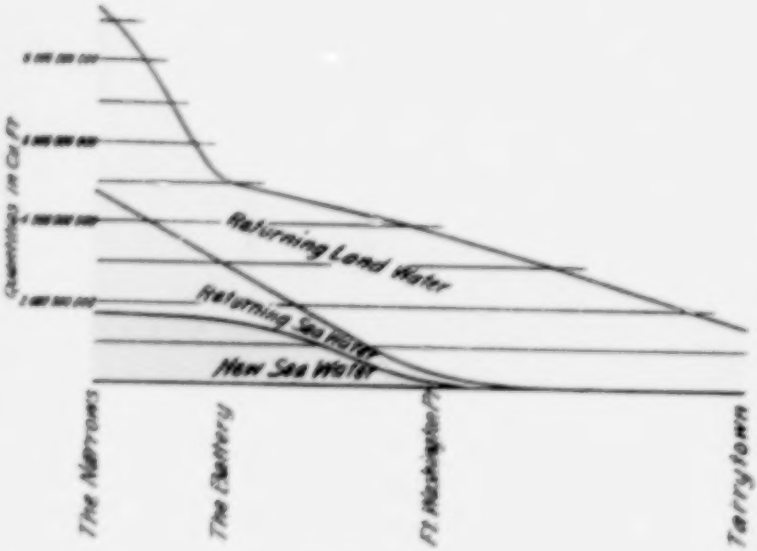
UPPER BAY AND HUDSON RIVER.
Division of Sea and Land Water
during April when Maximum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission



Ex. 91 - P. 31

UPPER BAY AND HUDSON RIVER
Division of Sea and Land Water
during April when Maximum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission.

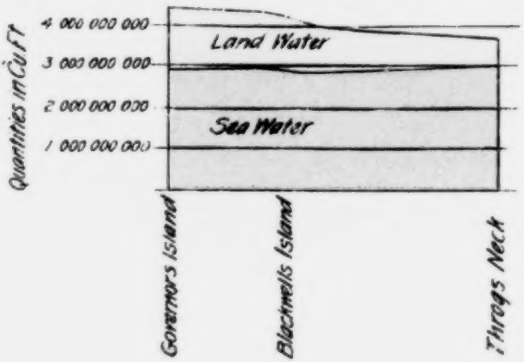
FLOOD CURRENT



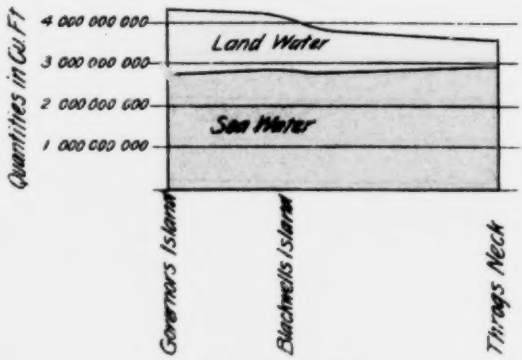
Ex. 91 - P. 32

EAST RIVER
Division of Sea and Land Water
when Average Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission.

EBB CURRENT

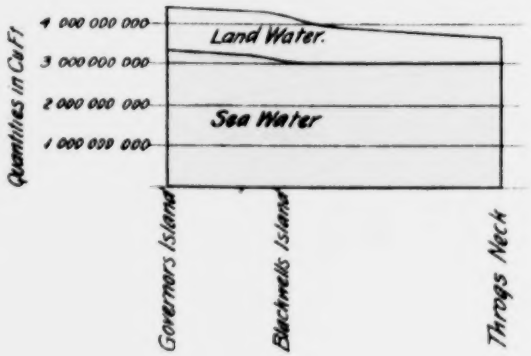


FLOOD CURRENT

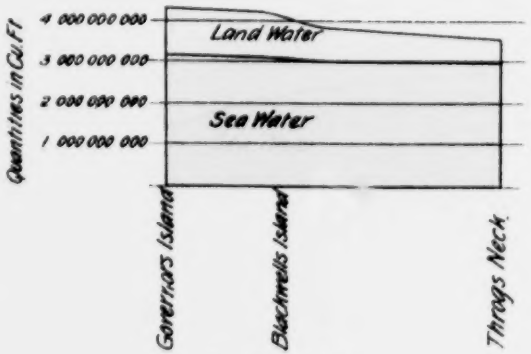


EAST RIVER
Division of Sea and Land Water
during August when Minimum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission.

EBB CURRENT



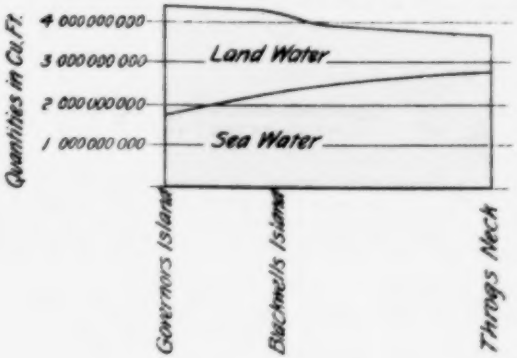
FLOOD CURRENT



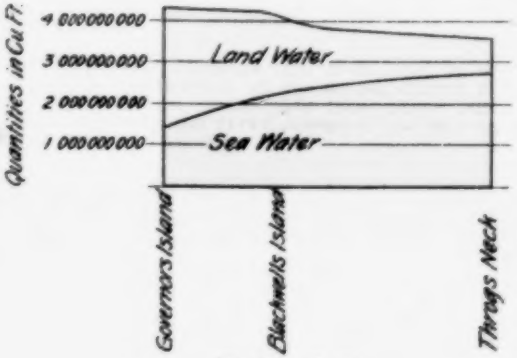
Ex. 91 - P. 34

EAST RIVER
Division of Sea and Land Water
during April, when Maximum Land Water is Flowing
from Salinometer Records made by The Metropolitan Sewerage Commission.

EBB CURRENT



FLOOD CURRENT



Ex. 91 - P. 35

In the Upper Bay the quantities of new sea and land-water available for dilution of sewage are as follows:-

	In Million Cu.Ft. per Tidal Cycle.		
	New Sea-Water.	New Land-Water.	Total.
Average for year	2,210	1,180	3,390
Least amount (February)	670	690	1,360
Least amount (Summer-August)	1,520	620	2,140

If the quantity of water available for dilution of sewage is taken as the resultant flow through The Narrows, then the quantities are

	In Million Cu.FT. per Tidal Cycle.
Average for year	1,260
Least amount (Winter-February)	770
Least amount (Summer-August)	700

The course followed by sewage discharged at Robbins Reef would be similar to those shown by the float experiments made by the Metropolitan Sewerage Commission. The paths of these floats are given in diagrams in the Report of the Commission, dated 30th April, 1910.

The floats show that the currents oscillate with the tides. On flood tides the sewage is liable to travel about 6 miles, and on ebb about 10 miles.

A particle set adrift off Robbins Reef in the main channel on flood tide would take four tidal cycles to remain outside of Sandy Hook; and if started on ebb tide would take three cycles. It would take two tidal cycles for the particle to remain outside of the Narrows if started on flood and one cycle if started on ebb. All these estimates are based on the assumption that the particle will remain in the sea-ward trend of the current and not get delayed by cross currents.

The effect of undertow.

When the tidal currents turn from flood to ebb or from ebb to flood, the inertia of the moving stream plays a very important part. The turn of the tide takes place first along the shore. In The Narrows, the first change of current appears on the east side of the channel.

As the specific gravity of the sea outside of New York bar is about 1.024, the sea-water is approximately 2½ heavier than the fresh water discharged from the rivers. As the tide

turns there is a tendency for this lighter fresh water to flow out over the top of the incoming heavier salt water. There also is a tendency, largely due to inertia, for the formation of top and bottom currents flowing in opposite directions, and for side currents flowing contrarywise to the channel current. Consequently an "underrun" is formed. This term is distinctly applied to the current that predominates along the bed of a channel in the opposite direction to that flowing on the surface at the same time.

The "underrun" of salt water up the Hudson River extends above Poughkeepsie, where the water is often found brackish, during those seasons when the river discharge of land-water is small.

Ex. 91 - P. 39

COMPLAINANTS' EXHIBIT No. 92. *James D. Maher, Commissioner.*

Current Observations Near Robbins Reef.

August 25, 1909.

H. W. G. I., 2.40 P. M.
L. W. G. I., 8.25 A. M.
10.40 A. M., Depth of Water, 52'.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
10–48–10	S'	270°	West New Brighton	5–35	.3	Faint S. W. breeze.
53–45						
10–53–10	20'	40°	Hudson R.	2–50	.59	
56–00						
10–57–30	40'	45°	Battery	1–30	1.47	
58–40						
11–00–00	S'	255°	100' S. of Robbins R.	7–30	.222	
07–30						
11–05–10	20'	30°	Liberty	2–45	.61	
07–55						
11–11–07	40'	45°	Pier A.	1–03	1.58	
12–10						
11–18–20	S'	340°	Inner end P. R. R. Fgt. Term. or Breakwater.	3–37	.469	
24–48						
11–20–00	20'	60°	Buttermilk Channel	1–37	.85	Calm.
21–37						
11–23–00	40'	40°	Hudson R.	1–30	1.11	
26–30						
11–30–00	S'	335°	P. R. R. Fgt. Term. Fgt. Ferry House.	5–15	.32	
35–15						
11–35–27	20'	40°	Hudson R.	2–00	.83	
37–27						
11–40–00	40'	45°	Pier A.	1–27	1.2	
41–23						
11–45–30	S'		1,000' S. of P. R. R. Fgt. Ferry Term.	3–15	.51	
48–45						

Current Observations Near Robbins Reef.

August 28, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
11-31-00	20'	45°	Pier A	1-17	1.39	
32-20						
11-55-00	40'	40°	Hudson	1-38	1.16	
56-26						
12-00-00	5'	340°	End of P. R. R. Fgt. Term. Pier or Breakwater.	2-45	.61	
02-45						
12-05-00	20'	30°	End N. J. Cent. Pier Communipaw	1-39	1.25	
06-20						
12-10-00	40'	30°	Liberty	1-32	1.60	Faint southerly breeze.
11-32						
12-20-20	5'	40°	Hudson	1-50*	.68	Using 75' line.
12-27-50	20'	45°	Pier A	1-19	1.26	
29-15						
12-31-30	40'	30°	100' E. gas buoy at P. R. R. Term. Channel G2.	1-16	1.31	
32-46						
12-36-40	5'	20°	½ dist. from Black Tom Water Tank to Liberty.	1-47?	.82	5' float with 88' of line from this time on till end of day.
31-47						
12-37-10	20'	30°	100' E. Gas buoy G2 at P. R. R. Term. Channel.	1-08	1.47	
38-18						
12-40-35	40'	40°	Hudson	1-18	1.33	" 20' same direction.
41-50						

* With 75 ft. distance.
? With 88 ft. distance.

Current Observations Near Robbins Reef.
August 23, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100', m. s.	Velocity, feet per second.	Wind.
12-43-00	5'	10°	Black Tom Island	2-00*	.73	
47-00						
12-50-00	20'	40°	Hudson	1-02	1.61	
51-02						
12-55-00	40'	40°	Hudson	1-15	1.38	
56-15						
1-00-00	5'	30°	Liberty	1-24*	1.04	
01-24						
1-06-00	20'	30°	100' E. of Gas Buoy G2	0-56	1.78	
06-56						
1-10-30	40'	40°	Hudson	0-56	1.78	
11-28						
1-15-00	5'	40°	Hudson	1-08*	1.29	
16-08						
1-23-35	20'	40°	Hudson	1-00	1.67	
24-35						
1-25-00	40'	30°	Gas Buoy G2	1-31	1.10	
26-31						
1-35-40	5'	20°	½ dist. from Black Tom to Liberty	1-13*	1.37	
36-53						
1-38-30	20'	25°	W. side Liberty Island	1-07	1.49	
39-37						
1-39-05	40'	40°	Hudson	1-20	1.25	Faint southerly breeze.
40-25						
1-45-00	5'	30°	Liberty	1-06*	1.33	
46-06						
1-50-00	20'	30°	Liberty	1-17	1.3	May have been slightly retarded by friction on another line.
51-17						
1-55-40	40'	20°	W. side Liberty Is.	1-55	.87	
57-35						

* For length of 88 feet.

August 23, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
2-10-00 01-40	5'	20°	⅓ way from Liberty to Black Tom...	1-30*	.98	Uranine discharged going in direction between Black Tom and end of P. R. R. Breakwater.
2-05-00 06-30	20'	30°	Liberty	1-30	1.11	
2-10-00 12-02	40'	30°	Liberty	2-02	.82	Uranine toward end P. R. R. Breakwater. Faint S. E. breeze.
2-15-04 16-32	5'	25°	200' W. of Liberty Is.....	1-28*	1.00	
2-20-00 21-52	20'	30°	Liberty	1-52	.89	
2-25-00 27-10	40'	40°	Hudson	2-10	.77	
2-30-00 32-00	5'	5°	½ way from Black Tom to end P. R. R. Fgt. Term. Breakwater.....	2-00*	.733	
2-35-00 37-40	20'	20°	½ way from Liberty to Black Tom..	2-40	.63	
2-40-00 43-40	40'	20°	⅓ way from Black Tom to Liberty...	3-46	.45	Faint southerly breeze.
2-45-00 47-45	5'	15°	½ way from Black Tom to Liberty Is.	2-45*	.53	Light South West breeze.
2-50-00 52-18	20'	20°	⅓ way from Liberty to Black Tom...	2-18	.72	

* For distance of 88 feet.

Current Observations Near Robbins Reef.

August 23, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'. m. s.	Velocity, feet per second.	Wind.
2–55–00 59–20	40′	30°	At first toward East R. Finally West of Liberty	4–20	.38	Swerved westward probably by influence of surface current on cord. Assume current toward Pier A.
3–00–02 03–30	5′	30°	do.	3–30*	.42	
3–05–00 07–37	20′	10°	Black Tom	2–37	.64	
3–10–00 14–30	40′	45°	Battery	4–30	.37	
3–15–00 19–10	5′	40°	Hudson	4–10*	.35	
3–20–00 25–15	20′	65°	Red Hook	5–15	.32	Surface current carrying cord to south.
3–25–00 33–00	40′	90°	At first toward Pier A. Finally Gowanus	8.00?	.21	Swerved southward by influence of surface current on cord. Assume current toward Fulton St., Brooklyn.
3–30–00 33–55	5′	140°	Bliss Tower	3–55*	0.37	Cord remained rather slack.
3–36–30 45–15	20′	100°	39th St. Ferry S. side Gowanus Bay.	8–45	.19	
3–40–10 52–30	40′	135°	Edison Chimney	12–20	.14	
3–45–30 48–10	5′	135°	Edison Chimney	2–40	.55	
3–50–00 53–30?	20′	135°	Between Edison and Bliss Tower	3–30	.48	
3–55–00 4–00–00	40′	145°	71st St., Brooklyn	5–00	.33	

* For distance of 88 feet.

August 23, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
4–00–15	5'	150°	75th St., Brooklyn.....	2–30*	.58	
02–45						
4–05–00	20'	150°	79th St., Brooklyn.....	2–24	.69	South S. W. breeze.
07–24						
4–10–00	40'	145°	71st St., Brooklyn.....	3–50	.43	
13–50						
4–15–00	5'	150°	79th St., Brooklyn.....	1–50*	.80	
16–50						
4–19–10	20'	170°	Fort Hamilton	1–45	.95	
20–55						
4–23–00	40'	150°	79th St.....	2–22	.70	Uranine on surface toward 71st, Brooklyn.
25–22						

* For distance of 88 feet.

Current Observations Near Robbins Reef.
August 24, 1909.

H. W. G. I., 9.30 A. M.
Depth, 45 feet.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'. m. s.	Velocity, feet per second.	Wind.
9–36–05	5′	225°	St. George Ferry.....	2–0	.83	Calm.
38–05						
9–37–20	20′	225°	St. George Public School.....	5–25	.31	
42–45						
9–40–50	40′	235°	St. George Public School.....	5–20	.31	
46–16						
9–45–00	5′	225°	St. George Ferry.....	1–25	1.18	
46–25						
9–55–00	20′	235°	St. George School.....	7–55	.21	Ran aground in 38′ water 50′ toward St. George School.
10–02–55						
9–55–00	40′					
10–00–10	5′	230°	Between St. Geo. Ferry and Sch'l...	2–15	.74	Calm.
02–25						
10–06–25	20′			12–35	.13	Balancing tension of cord 80′ toward Constable Hook.
19–00						
10–13–30	40′			11–30	.14	Balanced by tension on cord about 10′ W. of starting point. Aground on sounding find depth 39½′ only.
25–00						
10–13–30	5′	235°	St. George School.....	2–27	.68	
15–57						
10–24–15	20′			7–45	.21	Stationary about 80′ toward Robbins Reef. Balance by cord tension.
32–00						
10–26–03	40′					Re-anchored in 48′ of water.

August 24, 1909.—Continued.

Depth of Water, 48'.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
10–41–05	40'	45°	Opposite (away from) St. George Ferry	1–50	.91	Calm.
42–55						
10–45–00	5'	250°	W. New Brighton	4–22	.38	
49–22						
10–50–00	20'	315°	Opposite (away from) Edison Chimneys	6–40	.25	
56–40						
10–56–40	40'					Aground balanced by current against cord. Depth of water 38 ft.
11–02–00	5'	315°	Opposite Edison Chimneys	4–05	.41	
06–05						
11–14–30	20'	5°	Betw. Black Tom and end P. R. R. Breakwater	10–20	.15	Depth of water 67 ft. probably retarded by tension on cord.
24–50						
11–16–00	40'	45°	Opposite St. George Ferry House	2–21	.71	
18–21						
11–20–10	5'	315°	Opposite Edison Chimneys	4–35	.36	
24–45						
11–24–00	40'	30°	Liberty	1–47	.93	
25–47						
11–30–00	5'	120°	Opposite 53d St., Brooklyn	3–28	.48	
33–28						
11–30–00	20'	10°	Black Tom	4–53	.34	
34–53						
11–36–00	40'	40°	Hudson	54	1.85	
36–54						

August 24, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
11–40–00	5'	5°	Between Black Tom and end P. R. R.	2–14	.75	Faint southerly
42–14			Breakwater			breeze.
11–45–00	20'	40°	Hudson	1–43	.97	
46–43						
11–50–22	40'	40°	Hudson	0–48	2.08	
51–10						

Depth, 53 feet. Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'. m. s.	Velocity, feet per second.	Wind.
9–59–00	5'	210°	Stapleton Ferry House	3–30	.48	Southwest about 10 miles. Ebb tide.
10–02–30						
10–04–00	20'	210°	Stapleton Ferry House	2–00	.83	
06–00						
10–09–00	40'	185°	Ft. Wadsworth	5–00	.33	
14–00						
10–14–00	5'	165°	Ft. Hamilton	4–30	.37	
18–30						
10–19–00	20'	210°	Stapleton Ferry House	2–00	.83	
21–00						
10–27–00	40'	30°	Liberty Statue	10–00	.17	Started toward Ft Wadsworth. went 20' then turned toward Black Tom at 10:30. Passed boat at 10:31.
37–00						
10–33–00	5'	115°	53d St., Brooklyn	8–30	.20	
10–37–30	20'	210°	Stapleton Ferry House	4–00	.42	
41–30						
10–46–00	40'	65°	Red Hook Stores	5–00	.33	
47–00						
10–57–00	5'	10°	Black Tom	14–00	.12	Started toward Ft Wadsworth went 25' and turned back toward boat 11:00 At 11:07 lay along side boat.
79–00						
10–57–00	20'					
11–01–00	40'	30°	Liberty Statue	3–00	.55	
04–00						
11–02–00	5'	10°	Black Tom	13–00	.13	
15–00						
11–08–00	20'	30°	Liberty Island	13–00	.13	
11–21–00	40'	90°	Hudson River	2–00	.83	

August 25, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
11–21–30	5'	10°	Black Tom	3–00	.55	
24–30						
11–26–30	20'	10°	Black Tom	4–00	.42	
30–30						
11–32–00	40'	30°	Liberty Statue	1–30	1.11	
33–30						
11–37–00	5'	10°	Black Tom	2–30	.67	
39–30						
11–42–00	20'	10°	Black Tom	2–30	.67	
44–30						
11–47–00	40'	30°	Liberty Statue	1–30	1.11	
48–30						
11–52–00	5'	10°	Black Tom	2–30	.67	
54–30						
11–57–00	20'	10°	Black Tom	2–00	.83	
59–00						
12–02–00	40'	30°	Liberty Statue	1–30	1.11	
03–30						
12–07–00	5'	10°	Black Tom	2–00	.83	
09–00						
12–12–00	20'	30°	Liberty Statue	2–00	.83	
14–00						
12–17–00	40'	45°	Pier A	–45	2.22	
17–46						
12–22–00	5'	10°	Black Tom	2–00	.83	
24–00						
12–27–00	20'	30°	Liberty Statue	1–45	.95	
28–45						
12–30–00	40'	40°	Hudson River	–45	2.22	
30–45						

Current Observations Near Robbins Reef.

August 26, 1909.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
1-20-00	3'	40°	Hudson	4-30	0.37	
24-30						
1-27-00	20'	40°	Hudson	2-35	0.65	*N*
29-35						
1-33-00	50'	40°	Hudson	-42	2.38	
33-42						
1-38-00	3'	30°	Liberty	4-00	0.41	
42-00						
1-46-00	20'	80°	Erie Basin	1-10	1.42	
47-10						
1-52-00	50'	80°	Hudson	-30	3.33	
52-30						
1-57-00	3'	80°	Hudson	3-	0.55	
2-00-00						

September 1, 1909.

H. W. G. L., 8.41 A. M.
L. W. G. L., 3.00 P. M.
Depth, 67 feet.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
10-56-10	4'	167°		1-10	1.43	
57-20						
11-00-05	20'	180°		2-15	.74	
02-20						
11-05-00	40'	178°		2-24	.69	
01-24						
11-10-00	4'	172°		1-15	1.33	
11-15						
11-16-00	20'	190°		1-40	1.00	
17-40						
11-20-00	40'	180°		1-44	.96	
21-44						
11-25-00	4'	178°		1-08	1.47	Moderate west breeze.
26-08						
11-30-00	40'	180°		1-21	1.23	
31-21						
11-30-45	20'	193°		1-17	1.30	
32-02						
11-35-15	4'	185°		1-04	1.56	
36-10						
11-40-00	20'	197°		-55	1.82	
40-55						
11-45-00	40'	185°		1-08	1.47	
46-08						
11-50-00	4'	196°		-48	2.09	
50-48						

13—Ex. 28

September 1, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
11–58–00	20'	209°		00–54	1.85	
00–54						
12–00–00	40'	198°		–42	2.38	
00–42						
12–05–00	4'	203°		–54	1.85	
00–54						
12–10–00	20'	206°		–47	2.13	
00–47						
12–15–00	40'	203°		–48	2.08	
16–28						
12–20–15	4'	208°		–38	2.63	
21–03						
12–25–00	20'	202°		–43	2.32	Moderate N. N. W.
25–43						
12–30–00	40'	203°		–34	2.94	
00–34						
12–35–00	4'	210°		–38	2.63	
00–38						
12–40–00	20'	206°		–31	3.22	
00–31						
12–45–00	40'	205°		–28	3.57	
00–28						
12–50–00	4'	209°		–35	2.86	Faint northerly breeze.
00–35						
12–55–05	20'	215°		–36	2.78	
00–41						

September 1, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
1-05-10	4'	208°		00-31	3.22	
00-41						
1-10-00	20'			-28	3.85	
00-26						
1-14-30	40'	190°		-34	2.94	
15-04						
1-20-05	4'	203°		-32	3.12	
00-37						
1-25-00	20'	209°		-34	2.94	
00-34						
1-30-00	4'	206°		-29	3.33	Fresh north.
00-30						
1-35-00	20'	207°		-29	3.45	
00-29						
1-44-00	40'	200°		-29	3.45	
00-29						
1-46-00	4'	200°		-27	3.70	
00-27						
1-48-50	20'	228°		-31	3.22	
1-56-25	40'	220°		-28	3.57	
00-53						
2-01-10	20'	212°		-32	3.12	
00-51						
2-05-40	40'	212°		-35	2.86	
00-15						

September 1, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
2-12-00	4'	198°		00-30	3.33	
00-30						
2-19-10	20'	210°		-26	3.85	
00-36						
2-23-25	40'	207°		-27	3.70	Strong N. W.
00-52						
2-28-00	4'	200°		-32	3.12	
00-32						
2-34-36						Anchor dragged to 600' S. E. of Bell Buoy within 5 or 10 min. moved up depth of water 50'.
3-12-55	20'	213°		-45	2.22	Strong N. W.
13-40						
3-23-30	40'	215°		-53	1.89	
24-13						
3-31-00	4'	208°		-47	2.13	
00-47						
3-35-33	40'	205°		1-07?	1.40	
36-40						
3-44-07	20'	210°		-51	1.96	
00-58						
3-46-15	4'	208°		-42	2.38	
00-57						
3-50-10	20'	216°		-56	1.79	
51-12						
3-55-25	40'	205°		-56	1.79	
00-21						

Current Observations Near Robbins Reef.

September 1, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
3-59-30	4'	205°		00-46	2.50	
4-00-10						
4 03-45	40'	211°		1-07	1.49	
04-52						
4-09-11	20'	212°		-58	1.72	
10-09						
4-12-05	4'	215°		-47	2.13	
00-52						
4-27-02	20'	203°		1-01	1.59	
28-05						
4-33-52	40'	213°		1-33	1.07	
35-25						

Current Observations Near Robbins Reef.

September 3, 1909.

H. W. G. I., 10.20 A. M.
Depth of Water, 65 feet.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100′. m. s.	Velocity, feet per second.	Wind.
10–00–00	4′					r'aint westerly breeze.
10–05–00	20′	30°	Liberty	–37	2.70	
00–37						
10–10–13	40′	30°	Liberty	–38	2.63	
00–38						
10–07–00	4′	40°	¼ way Pier A to Jersey City	–35	2.86	
00–35						
10–15–00	4′	30°	Liberty	–34	2.94	
00–34						
10–20–00	20′	40°	Hudson	–36	2.78	
00–36						
10–25–00	40′	40°	½ min. W. of Pier A	–39	2.56	
00–39						
10–30–00	4′	30°	Liberty	–42	2.38	
33–35	4′					
34–17						
10–35–00	20′	30°	Liberty	–34	2.94	
37–15	40′					
00–49						
10–42–00	4′	20°	Between Liberty and Black Tom	–37	2.70	Calm.
00–37						
10–48–30	40′	40°	½ min. W. of Pier A	–51	1.96	
49–21						
10–50–40	20′	20°	Between Liberty and Black Tom	–46	2.17	
51–26						

September 3, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100′.	Velocity, feet per second.	Wind.
				m. s.		
10–55–00	4′	25°	250′ W. of Liberty.....	00–45	2.22	Calm.
00–45						
11–00–00	20′	40°	Hudson	–46	2.17	
00–46						
11–05–00	40′	30°	Liberty	–53	1.89	
11–05	4′					
00–58						
11–14–00	20′	40°	¼ dist. Pier A, across Hudson.....	–56	1.78	
00–56						
11–16–15	40′	40°	Hudson	1–02	1.61	
17–17						
11–20–00	4′	35°	¼ way Liberty to Pier "A".....	1–18	1.28	
21–18						
11–25–00	20′	30°	Liberty	–58	1.72	
00–58						
11–30–00	40′	40°	Hudson	1–10	1.43	
31–10						
11–35–00	4′	40°	Hudson	1–15	1.33	
36–15						
11–40–00	20′	40°	Hudson	1–21	1.23	Gentle S. E. breeze.
41–21						
11–46–15	40′	45°	Pier A.....	1–33	1.07	
49–05	40′					
56–38						
11–52–00	4′	30°	Liberty	1–29	1.12	
53–29						

September 3, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
11–55–00	20′	55°	Opposite St. George School.....	1–49	.92	
59–00	20′					
12–00–49						
12–05–00	40′	55°	do.	3–25	.49	S. E. breeze.
08–25						
12–11–00	4′	105°	300′ S. of B. R. T. Chimney.....	3–06	.54	
14–06						
12–16–00	20′	100°	38th St., Brooklyn.....	5–02	.33	
21–02						
12–24–00	40′	40°	Hudson River	2–35	.64	
26–35						
12–29–00	4′	120°	300′ N. of Edison Chimney.....	2–38	.63	
30–30	4′					
33–08						
12–35–30	20′	85°	Erie Basin	2–25	.69	
37–55						
12–40–00	40′	200°	Spire at Clifton.....	2–44	.61	
43–00	40′					
45–44						
12–45–00	4′	200°	do.	1–13	1.37	
46–13						
12–50–00	20′	210°	Stapleton	1–52	.89	Faint S. E. breeze.
51–52						
12–55–00	40′	210°	do.	1–41	.99	
56–41						

Current Observations Near Robbins Reef.

September 3, 1909.—Continued.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
1-02-00	4'	210°	Stapleton	1-11	1.41	
03-11						
1-05-00	20'	205°	Between Stapleton and Clifton.....	1-14	1.35	
06-14						
1-10-00	40'	205°	Between Stapleton and Clifton.....	1-46	.99	
11-46						
1-15-00	4'	200°	Clifton Spire	1-00	1.67	Faint southwesterly breeze.
16-00						
1-20-00	20'	210°	Stapleton	1-04	1.56	
21-04						
1-25-00	40'	210°	Stapleton	1-07	1.49	
33-00	40'					
34-07						

Current Observations Near Robbins Reef.

October 11, 1909.

H. W. G. I., 6.21 A. M.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				m. s.		
1-54-20	4'	250°		1-06	1.50	Clear — wind East — strong.
55-26						
2-11-3	20'	255°		2-07	0.79	
13-10						
2-24-00	40'	260°				
31-00					0.05	
55-00		266°	85' out			
2-58-14	4'	270°		2-04	0.81	
3-00-18						
3-11-55	20'	320°		4-25	0.38	
16-20						
3-27-48	40'	300°	85' out	6-46	0.21	
34-34						
3-49-20	20'	5°		2-00	0.83	
51-20						
4-08-00	4'	20°		1-23	1.20	
4-20-00	4'					
21-23						

Current Observations Near Robbins Reef.

October 22, 1909.

Time.	Depth.	Angle from north.	Direction towards.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
				s.		
9–55–00	4′	275°	R. R. Light House	380	.26	South-light—Overcast.
10–01–20						
10–05–00	20′	340°	P. R. R. Term	400	.25	
11–40						
10–15–00	40′	30°	South of Liberty	100	1.00	
16–40						
10–25–00	4′	340°	P. R. R. Term	380	.26	
31–20						
10–35–00	20′	15°	Black Tom Island	200	.50	
38–20						
10–40–00	40′	30°	South of Liberty	100	1.00	
41–40						
10–50–00	4′	15°	Black Tom Island	190	.53	
53–10						
11–00–00	20′	35°	Up Hudson River	105	.95	
01–45						
11–10–00	40′	45°	Pier A	70	1.43	
11–10						
11–20–00	4′					

24 *Current Observations Near Robbins Reef.*

December 7, 1909. H. W. G. I., 4:35 P. M.

Overcast. Sounding 9:30 A. M. = 60'.

Time.	Depth.	Direction or angle from north.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
			s.		
9–45–00	2'	215°	55	1.81	East-light.
45–55					
10–00–40	20'	215°	40	2.50	
01–20					
10–12–54	40'	209°	43	2.32	
13–37					
10–19–00	2'	212°	45	2.22	
19–45					
10–27–00	20'	208°	44	2.27	
27–44					
10–35–00	40'	200°	45	2.22	
35–45					
10–45–00	2'	211°	43	2.32	
45–43					
10–52–00	20'	210°	50	2.00	
52–50					
11–00–00	40'	210°	52	1.92	
00–52					
11–10–00	2'	215°	58	1.72	
10–58					
11–15–00	20'	220°	70	1.42	
16–10					
11–20–00	40'	220°	78	1.28	
21–18					
11–30–00	2'	214°	64	1.56	
31–04					

Current Observations Near Robbins Reef.

December 8, 1900. H. W. G. I., 5:00 A. M.

Time.	Depth.	Direction or angle from north.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
			s.		
10-00-00	2'	200°	54	1.85	Strong S. W.—Clear.
00-54					
10-08-00	20'	192°	45	2.22	
08-45					
10-11-00	40'	190°	47	2.12	
11-47					
10-18-00	2'	205°	60	1.67	
19-00					
10-26-00	20'	200°	67	1.49	
27-07					
10-30-00	40'	190°	88	1.14	
31-28					

26 *Current Observations Near Robbins Reef.*

December 10, 1906. H. W. G. I., 6:05 A. M.

Time.	Depth.	Direction or angle from north.	Elapsed time for 100'.	Velocity, feet per second.	Wind.
			m.		
1-30-00	2'	200°	47	2.12	Strong N. W.—Fair.
30-47					
1-47-00	40'	190°	44	2.27	
47-44					
2-01-00	2'	196°	45	2.22	
01-45					
2-10-00	20'	195°	47	2.13	
10-47					
2-20-00	40'	198°	52	1.92	
20-52					
2-29-00	2'	200°	60	1.67	
30-00					
2-40-00	20'	215°	75	1.33	
41-15					
2-50-00	40'	220°	115	0.87	
51-55					
3-01-00	2'	220°	120	0.83	
03-00					
3-11-00	20'	228°	140	0.71	
13-20					
3-20-00	40'	260°	200	0.50	
23-20					
3-30-00	2'	230°	165	.61	Boat swings.
32-45					
3-40-00	20'	200°	250	.40	
44-10					
3-51-00	40'	352°	360	.28	
57-00					
4-00-00	2'	205°	300	.20	
05-00	60'		500		
4-12-00	20'	45°	180	.28	
15-00	50'		360		

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

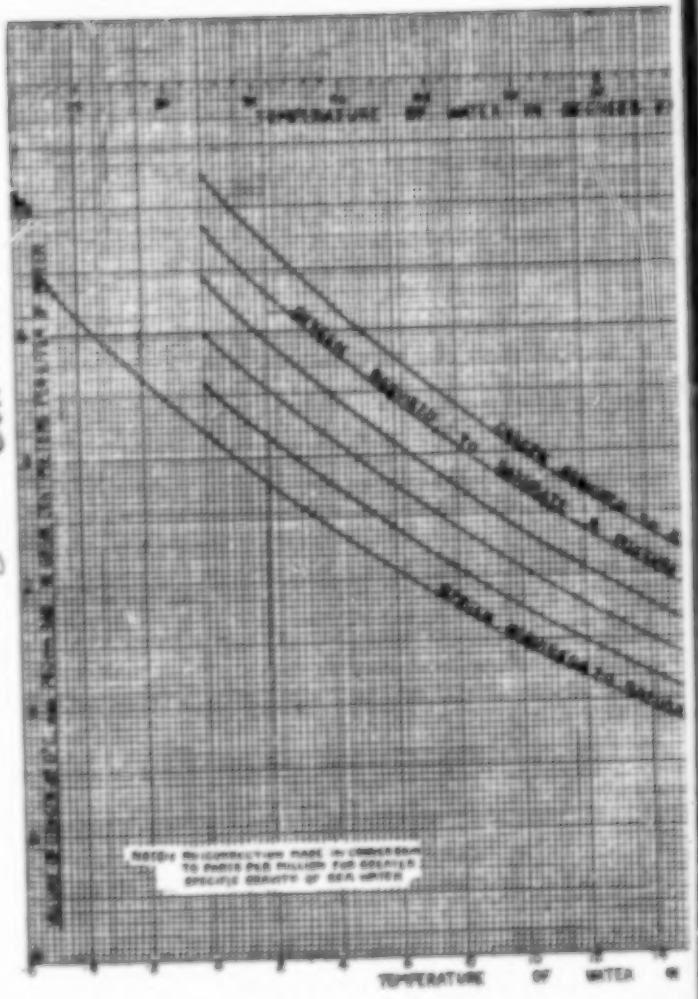
vs.

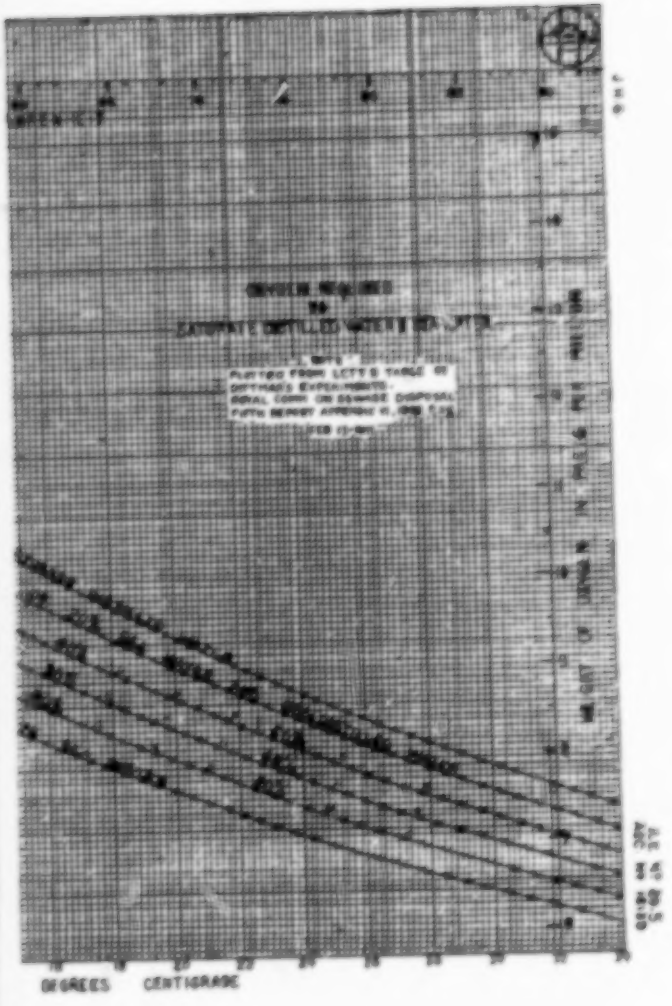
STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 93.

JAMES D. MAHER,
Commissioner.

Complainants Exhibit No. 93
James B. Marks
Commissioner




DEGREES CENTIGRADE

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 94.

JAMES D. MAHER,
Commissioner.

Dissolved Oxygen. Buttermilk Channel, East river. June 27, 1911.

High water at Governors Island at 8.33 a.m. Low water at 2.57 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent bund water	Oxygen — C.C. per litre	Oxygen — Percent saturation
1	11.00	Slip just east of pier 32, East river, Brooklyn	Lat 40 41 15 Long 74 00 28	1	Ebb	20.5	36	1.56	27
2	11.02	Slip just east of pier 32, East river, Brooklyn	Lat 40 41 15 Long 74 00 26	10	Ebb	20.5	36	1.56	27
3	11.20	Buttermilk Channel, 200 feet off pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	1	Ebb	20	34	3.11	54
4	11.23	Buttermilk Channel, 200 feet off pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	20	Ebb	20	34	3.11	54
5	11.30	Buttermilk Channel, 200 feet off pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	35	Ebb	20	34	3.11	43
6	12.00	Buttermilk Channel, 200 feet off outer end of De Graw St. Slip	Lat 40 41 15 Long 74 00 32	1	Ebb	20	34	2.49	43
7	12.02	Buttermilk Channel, 200 feet off outer end of De Graw St. slip	Lat 40 41 15 Long 74 00 32	20	Ebb	20	34	2.49	43
8	12.05	Buttermilk channel, 200 feet off outer end of De Graw St. slip	Lat 40 41 15 Long 74 00 32	35	Ebb	20	34	2.49	43
9	12.30	Buttermilk Channel, 200 feet off east end of pier 33, Brooklyn	Lat 40 41 11 Long 74 00 35	1	Ebb	20	34	2.49	43
10	12.32	Buttermilk Channel, 200 feet off east end of pier 33, Brooklyn	Lat 40 41 11 Long 74 00 35	20	Ebb	20	34	2.49	43
11	12.35	Buttermilk Channel, 200 feet off east end of pier 33, Brooklyn	Lat 40 41 11 Long 74 00 35	30	Ebb	20	34	2.49	43

Complainant's Exhibit No. 94
James Duane
Commissioner

Ex. 94. p.1

Dissolved Oxygen. Gowanus Canal. June 27, 1911.

High water at Governors Island at 8.33 a.m. Low water at 2.57 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
12	1.20	Gowanus Canal at its mouth, foot of 25 St., Brooklyn	Lat 40 39 55 Long 74 00 25	1	Flood	20.5	34	2.18	38
13	1.23	Gowanus Canal at its mouth, foot of 25 St., Brooklyn	Lat 40 39 55 Long 74 00 25	10	Flood	20.5	34	2.18	38
14	1.45	Gowanus Canal at Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	1	Flood	20.5	34	0.47	8
15	1.48	Gowanus Canal at Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	10	Flood	20.5	34	0.47	8
16	2.00	Gowanus Canal at 9th St. bridge	Lat 40 40 25 Long 73 59 50	1	Flood	20.5	34	0	0
17	2.03	Gowanus Canal at 9th St. bridge	Lat 40 40 25 Long 73 59 50	10	Flood	20.5	34	0	0
18	2.30	Gowanus Canal at Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	1	Flood	20.5	34	0.94	16
19	2.35	Gowanus Canal at Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	10	Flood	20.5	34	1.24	21

Dissolved Oxygen. Hudson river. June 28, 1911.

High water at Governors Island at 9.05.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent satura-tion
20	5.10	Hudson river, 500 feet off Inwood	Lat 40 32 15 Long 73 56 00	1	Ebb	22	76	3.43	57
21	5.15	Hudson river, 500 feet off Inwood	Lat 40 32 15 Long 73 56 00	1	Ebb	22	76	3.96	66
22	5.20	Hudson river, 500 feet off Inwood	Lat 40 32 15 Long 73 56 00	30	Ebb	22	68	3.74	62

Dissolved Oxygen. Hudson River Cross-section at Mt. St. Vincent. June 29, 1911.

High water at Governors Island at 10.25 a.m. Low water at 4.47 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
23	9.40	300 feet off Mt. St. Vincent dock	Lat 40 54 30 Long 73 54 46	1	Flood	72	84	4.08	68
24	9.42	300 feet off Mt. St. Vincent dock	Lat 40 54 30 Long 73 54 46	20	Flood	72	80	3.74	62
25	9.45	300 feet off Mt. St. Vincent dock	Lat 40 54 30 Long 73 54 46	30	Flood	72	76	3.74	62
26	10.10	1/4 way across from New York shore	Lat 40 54 30 Long 73 54 39	1	Flood	72	80	4.08	68
27	10.12	1/4 way across from New York shore	Lat 40 54 30 Long 73 54 39	20	Flood	72	72	3.74	62
28	10.15	1/4 way across from New York shore	Lat 40 54 30 Long 73 54 39	40	Flood	72	72	3.74	62
29	10.40	Midstream	Lat 40 54 30 Long 73 55 12	1	Flood	72	80	4.08	68
30	10.42	Midstream	Lat 40 54 30 Long 73 55 18	20	Flood	72	72	4.08	68
31	10.45	Midstream	Lat 40 54 30 Long 73 55 18	30	Flood	72	72	4.08	68
32	11.20	3/4 way across from New York shore	Lat 40 54 30 Long 73 55 30	1	Flood	72	80	4.32	72
33	11.22	3/4 way across from New York shore	Lat 40 54 30 Long 73 55 30	10	Flood	72	76	4.08	68
34	11.25	3/4 way across from New York shore	Lat 40 54 30 Long 73 55 30	20	Flood	72	72	4.08	68
35	11.55	300 feet off New Jersey shore	Lat 40 54 30 Long 73 55 42	1	Flood	72	80	4.32	72
36	11.57	300 feet off New Jersey shore	Lat 40 54 30 Long 73 55 42	10	Flood	72	76	4.32	72
37	12.00	300 feet off New Jersey shore	Lat 40 54 30 Long 73 55 42	18	Flood	72	76	4.32	72

STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3450

Sample No.	Hour P M.	Location of Samples Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C.	Per cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
38	3.20	300' off Mt. St. Vincent dock	Lat 40 54 50 Long 73 54 46	1	Ebb	23	80	4.05	68
39	3.23	300' off Mt. St. Vincent dock	Lat 40 54 50 Long 73 54 46	20	Ebb	23	78	4.05	68
40	3.25	300' off Mt. St. Vincent dock	Lat 40 54 50 Long 73 54 46	30	Ebb	23	72	3.74	62
41	3.52	1/4 way across from New York shore	Lat 40 54 50 Long 73 54 59	1	Ebb	23	80	4.05	68
42	3.53	1/4 way across from New York shore	Lat 40 54 50 Long 73 54 59	20	Ebb	23	76	4.05	68
43	3.55	1/4 way across from New York shore	Lat 40 54 50 Long 73 54 59	40	Ebb	23	72	3.74	62
44	4.10	Midstream	Lat 40 54 50 Long 73 55 15	1	Ebb	23	80	4.33	72
45	4.12	Midstream	Lat 40 54 50 Long 73 55 15	20	Ebb	23	76	4.33	72
46	4.15	Midstream	Lat 40 54 50 Long 73 55 15	30	Ebb	23	72	4.05	68
47	4.30	3/4 way across from New York shore	Lat 40 54 50 Long 73 55 30	1	Ebb	23	84	4.60	78
48	4.32	3/4 way across from New York shore	Lat 40 54 50 Long 73 55 30	10	Ebb	23	80	4.23	72
49	4.35	3/4 way across from New York shore	Lat 40 54 50 Long 73 55 30	20	Ebb	23	76	4.05	68
50	4.50	300' off New Jersey shore	Lat 40 54 50 Long 73 55 42	1	Ebb	23	84	4.60	78
51	4.52	300' off New Jersey shore	Lat 40 54 50 Long 73 55 42	10	Ebb	23	80	4.23	72
52	4.55	300' off New Jersey shore	Lat 40 54 50 Long 73 55 42	15	Ebb	23	76	4.23	72

Dissolved Oxygen.

East River Cross-section from College Point to Glason Point. June 30, 1911.

High water at Governors Island at 11.23 a.m. Low water at 5.27 p.m. High water at Hell Gate at 1.20 p.m. Low water at 7.15 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Per-cent land water	Oxygen — C.C. per litre	Oxygen — Percent saturation
53	11.00	200 feet off Glason Point dock	Lat 40 48 18 Long 73 51 11	1	Flood	20	28	3.43	60
54	11.02	200 feet off Glason Point dock	Lat 40 48 18 Long 73 51 11	20	Flood	20	28	3.27	57
55	11.04	200 feet off Glason Point dock	Lat 40 48 18 Long 73 51 11	40	Flood	20	26	3.11	55
56	11.25	1/4 way across from Glason Pt.	Lat 40 49 09 Long 73 51 11	1	Flood	20	28	3.43	60
57	11.27	1/4 way across from Glason Pt.	Lat 40 49 09 Long 73 51 11	20	Flood	20	28	3.27	57
58	11.30	1/4 way across from Glason Pt.	Lat 40 49 09 Long 73 51 11	40	Flood	20	30	3.11	55
59	11.46	Midstream	Lat 40 48 00 Long 73 51 11	1	Flood	20	30	3.11	55
60	11.48	Midstream	Lat 40 48 00 Long 73 51 11	20	Flood	20	28	3.11	55
61	11.50	Midstream	Lat 40 48 00 Long 73 51 11	40	Flood	20	26	3.11	55
62	12.06	3/4 way across from Glason Pt.	Lat 40 47 51 Long 73 51 11	1	Flood	20	28	3.11	55
63	12.08	3/4 way across from Glason Pt	Lat 40 47 51 Long 73 51 11	20	Flood	20	26	3.11	55
64	12.10	3/4 way across from Glason Pt.	Lat 40 47 51 Long 73 51 11	40	Flood	20	26	3.11	55
65	12.26	300 feet off College Point	Lat 40 47 44 Long 73 51 11	1	Flood	20	28	3.11	55
66	12.28	300 feet off College Point	Lat 40 47 44 Long 73 51 11	20	Flood	20	26	3.27	57
67	12.30	300 feet off College Point	Lat 40 47 44 Long 73 51 11	35	Flood	20	26	3.27	57

Dissolved Oxygen. East River Cross-section from Old Ferry Point to Whitestone Point. June 30, 1911.

High water at Governors Island at 11.33 a.m. Low water at 5.27 p.m. High water at Hell Gate at 1.20 p.m. Low water at 7.18 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
68	1.00	500 feet off Old Ferry Point	Lat 40 48 16 Long 73 49 49	1	Flood	21	24	4.68	85
69	1.02	500 feet off Old Ferry Point	Lat 40 48 16 Long 73 49 49	20	Flood	21	24	4.68	85
70	1.04	500 feet off Old Ferry Point	Lat 40 48 16 Long 73 49 49	50	Flood	21	24	5.00	91
71	1.16	Midstream	Lat 40 48 10 Long 73 49 38	1	Flood	21	24	4.68	85
72	1.18	Midstream	Lat 40 48 10 Long 73 49 38	20	Flood	21	24	4.68	85
73	1.20	Midstream	Lat 40 48 10 Long 73 49 38	50	Flood	21	24	5.00	91
74	1.36	500 feet off Whitestone Pt.	Lat 40 48 04 Long 73 49 18	1	Flood	21	24	4.68	85
75	1.38	500 feet off Whitestone Pt.	Lat 40 48 04 Long 73 49 18	20	Flood	21	24	5.00	91
76	1.40	500 feet off Whitestone Pt.	Lat 40 48 04 Long 73 49 18	50	Flood	21	24	5.00	91

Dissolved Oxygen.

East River Cross-section from College Point to Glason Point. June 30, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
77	2.20	200 feet off Glason Pt. dock	Lat 40 48 15 Long 73 51 11	1	Ebb	21	26	4.33	79
78	2.22	200 feet off Glason Pt. dock	Lat 40 48 15 Long 73 51 11	20	Ebb	21	24	4.33	79
79	2.24	200 feet off Glason Pt. dock	Lat 40 48 15 Long 73 51 11	40	Ebb	21	24	4.05	74
80	2.39	1/4 way across from Glason Pt.	Lat 40 48 09 Long 73 51 11	1	Ebb	21	26	4.33	79
81	2.41	1/4 way across from Glason Pt.	Lat 40 48 09 Long 73 51 11	20	Ebb	21	24	4.33	79
82	2.43	1/4 way across from Glason Pt.	Lat 40 48 09 Long 73 51 11	40	Ebb	21	24	4.05	74
83	2.57	Midstream	Lat 40 48 00 Long 73 51 11	1	Ebb	21	26	4.33	79
84	2.59	Midstream	Lat 40 48 00 Long 73 51 11	20	Ebb	21	24	4.33	79
85	3.01	Midstream	Lat 40 48 00 Long 73 51 11	40	Ebb	21	24	4.05	74
86	3.16	3/4 way across from Glason Pt.	Lat 40 47 51 Long 73 51 11	1	Ebb	21	26	4.33	79
87	3.16	3/4 way across from Glason Pt.	Lat 40 47 51 Long 73 51 11	20	Ebb	21	24	4.33	79
88	3.20	3/4 way across from Glason Pt.	Lat 40 47 51 Long 73 51 11	40	Ebb	21	24	4.05	74
89	3.35	300 feet off College Point	Lat 40 47 44 Long 73 51 11	1	Ebb	21	26	4.33	79
90	3.37	300 feet off College Point	Lat 40 47 44 Long 73 51 11	20	Ebb	21	24	4.33	79
91	3.40	300 feet off College Point	Lat 40 47 44 Long 73 51 11	35	Ebb	21	24	4.05	74

Dissolved Oxygen. East River from Battery to Lawrence Point.

July 5, 1911.

High water at Governors Island at 4 p.m. Low water at 9.47 a.m. High water at Hell Gate at 5.50 p.m. Low water at 11.23 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
92	9.50	Midway between Governors Island and Battery	Lat 40 41 50 Long 74 00 56	1	Ebb	23	38	3.11	55
93	9.51	Midway between Governors Island and Battery	Lat 40 41 50 Long 74 00 56	20	Ebb	23	38	3.11	55
94	9.53	Midway between Governors Island and Battery	Lat 40 41 50 Long 74 00 56	30	Ebb	23	38	3.11	55
95	10.13	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	1	Ebb	23	38	2.96	53
96	10.14	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	20	Ebb	23	38	3.11	55
97	10.16	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	40	Ebb	23	38	3.11	55
98	10.36	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	1	Ebb	23	38	2.96	53
99	10.37	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	20	Ebb	23	38	3.11	55
100	10.40	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	40	Ebb	23	36	3.11	55
101	11.00	At Queensboro bridge, middle of E. Channel	Lat 40 45 21 Long 73 57 08	1	Ebb	23	36	3.11	55
102	11.01	At Queensboro bridge, middle of E. Channel	Lat 40 45 21 Long 73 57 08	20	Ebb	23	36	3.11	55
103	11.03	At Queensboro bridge, middle of E. Channel	Lat 40 45 21 Long 73 57 08	35	Ebb	23	36	3.11	55
104	11.20	Hell Gate, midway between Hallet's Pt. and Mill Rock	Lat 40 46 44 Long 73 56 15	1	Ebb	23	32	3.11	57

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3157

Dissolved Oxygen. East River from Battery to Lawrence Point.

(Continued.) July 5, 1911.

Sample No.	Hour a.m.	Location of Samples			Tidal Current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent satura-tion
		Approximate	Exact ° ' "	Feet below surface					
105	11.21	Hell Gate, midway between Hallet's Pt. and Mill Rock	Lat 40 46 44 Long 73 56 15	30	Ebb	23	32	3.11	37
106	11.25	Hell Gate, midway between Hallet's Pt. and Mill Rock	Lat 40 46 44 Long 73 56 15	60	Ebb	22	32	3.11	37
107	11.40	Midway between Lawrence Point and Stony Point	Lat 40 47 35 Long 73 54 40	1	Ebb	21	28	3.74	44
108	11.41	Midway between Lawrence Point and Stony Point	Lat 40 47 35 Long 73 54 40	30	Ebb	23	28	4.05	74
109	11.43	Midway between Lawrence Point and Stony Point	Lat 40 47 35 Long 73 54 40	60	Ebb	27	28	4.33	78

Dissolved Oxygen — East River-Battery to Lawrence Point — July 8, 1911

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C.	Per cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
110	3.00	Midway between Governors Is. (N.dock)and Battery Park (Barge office)	Lat 40 41 50 Long 74 00 56	1	Flood	23	40	3.74	67
111	3.01	Midway between Governors Is. (N.dock)and Battery Park (Barge office)	Lat 40 41 50 Long 74 00 56	20	Flood	23	36	3.74	67
112	3.03	Midway between Governors Is. (N.dock and Battery Park (Barge office)	Lat 40 41 50 Long 74 00 56	30	Flood	23	28	3.74	67
113	3.23	At Brooklyn Bridge-midstream	Lat 40 42 20 Long 73 59 48	1	Flood	23	36	3.43	61
114	3.24	At Brooklyn Bridge-midstream	Lat 40 42 20 Long 73 59 48	20	Flood	23	36	3.43	61
115	3.26	At Brooklyn Bridge-midstream	Lat 40 42 20 Long 73 59 48	40	Flood	22	32	3.43	59
116	3.45	At Williamsburg Bridge midstream	Lat 40 42 49 Long 73 58 21	1	Flood	23	36	3.11	56
117	3.46	At Williamsburg Bridge midstream	Lat 40 42 49 Long 73 58 21	20	Flood	23	36	3.11	56
118	3.48	At Williamsburg Bridge midstream	Lat 40 42 49 Long 73 58 21	40	Flood	23	36	3.11	56
119	4.16	At Queensboro Bridge midstream	Lat 40 45 21 Long 73 57 08	1	Flood	23	40	3.11	56
120	4.19	At Queensboro Bridge midstream	Lat 40 45 21 Long 73 57 08	20	Flood	23	36	3.11	56
121	4.21	At Queensboro Bridge midstream	Lat 40 45 21 Long 73 57 08	35	Flood	23	30	3.11	56

Dissolved Oxygen East River July 8, 1911

High water occurred at Hell Gate at 5.50 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
122	4.40	Hell Gate midway between Hallet's Point and Mill Rock	Lat	40	46	44	1	Flood	22	40	5.11	88
			Long	73	86	15						
123	4.41	Hell Gate midway between Hallet's Point and Mill Rock	Lat	40	46	44	30	Flood	23	36	5.11	88
			Long	73	86	15						
124	4.43	Hell Gate midway between Hallet's Point and Mill Rock	Lat	40	46	44	60	Flood	23	34	5.11	88
			Long	73	86	15						
125	5.03	Midway between Stony Point and Lawrence Point	Lat	40	47	38	1	Flood	23	36	5.11	88
			Long	73	84	40						
126	5.04	Midway between Stony Point and Lawrence Point	Lat	40	47	38	30	Flood	23	34	5.11	88
			Long	73	84	40						
127	5.06	Midway between Stony Point and Lawrence Point	Lat	40	47	38	60	Flood	23	34	5.11	88
			Long	73	84	40						

Dissolved Oxygen — Gowanus Canal — July 6, 1911

High water occurred at Governors Island at 4.58 p.m. Low water at 10.27 a.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C.	Percent land water	Oxygen — c.c. per litre	Oxygen — Percent saturation
128	2.50	Gowanus bay near anchorage buoy at outer end of bay	Lat 40 39 45 Long 74 01 20	1	Flood	25.6	36	6.06	78
129	2.51	Gowanus bay near anchorage buoy at outer end of bay	Lat 40 39 45 Long 74 01 20	18	Flood	25.6	36	4.06	78
130	2.55	Gowanus bay near anchorage buoy at outer end of bay	Lat 40 39 45 Long 74 01 20	30	Flood	25.6	34	3.74	70
131	3.00	Gowanus canal at south-foot of 28th St.	Lat 40 39 58 Long 74 00 28	1	Flood	24	36	8.11	97
132	3.04	Gowanus canal at south-foot of 28th St.	Lat 40 39 58 Long 74 00 28	18	Flood	24	36	8.11	97
133	3.22	At Hamilton Ave. Bridge	Lat 40 40 17 Long 73 59 36	1	Flood	24.5	36	3.38	42
134	3.25	At Hamilton Ave. Bridge	Lat 40 40 17 Long 73 59 36	18	Flood	24.5	36	2.81	88
135	4.00	At 9th St. Bridge	Lat 40 40 28 Long 73 59 30	1	Flood	24.8	36	1.06	29
36	4.02	At 9th St. Bridge	Lat 40 40 28 Long 73 59 30	18	Flood	24.8	36	1.16	40

FOURTH OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1929

Dissolved Oxygen - Hudson River-Battery to Yonkers July 7th, 1911.

High water occurred at Governors Island at 5.23 p.m. Low water at 11.27 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
137	9.00	Midway between Pier A and C.R.R. of N.J.ferry, Jersey City	Lat 40 42 19 Long 74 01 34	1	Ebb	24.5	46	3.43	63
138	9.01	Midway between Pier A and C.R.R. of N.J.ferry, Jersey City	Lat 40 42 19 Long 74 01 34	20	Ebb	24	42	3.43	63
139	9.03	Midway between Pier A and C.R.R. of N.J.ferry, Jersey City	Lat 40 42 19 Long 74 01 34	40	Ebb	24	34	3.43	63
140	9.20	Off Canal St. Midstream	Lat 40 43 38 Long 74 01 17	1	Ebb	24.5	54	3.43	63
141	9.21	Off Canal St. Midstream	Lat 40 43 38 Long 74 01 17	20	Ebb	24	48	3.43	62
142	9.23	Off Canal St. Midstream	Lat 40 43 38 Long 74 01 17	40	Ebb	24	40	3.43	62
143	9.40	Off 23d St. Midstream	Lat 40 45 09 Long 74 01 00	1	Ebb	25	60	3.27	58
144	9.41	Off 23d St. Midstream	Lat 40 45 09 Long 74 01 00	20	Ebb	24.5	52	3.11	55
145	9.43	Off 23d St. Midstream	Lat 40 45 09 Long 74 01 00	40	Ebb	24	44	3.11	57
146	10.00	Off W.42d St. Midstream	Lat 40 45 50 Long 74 00 35	1	Ebb	25	66	3.11	54
147	10.01	Off W.42d St. Midstream	Lat 40 45 50 Long 74 00 35	20	Ebb	24.5	52	3.43	62
148	10.03	Off W.42d St. Midstream	Lat 40 45 50 Long 74 00 35	40	Ebb	24	44	3.74	69
149	10.23	Off W.72d St. Midstream	Lat 40 47 02 Long 73 59 42	1	Ebb	25	70	4.05	70
150	10.24	Off W.72d St. Midstream	Lat 40 47 02 Long 73 59 42	20	Ebb	24.5	56	4.05	73
151	10.26	Off W.72d St. Midstream	Lat 40 47 02 Long 73 59 42	40	Ebb	24	52	4.05	75

Dissolved Oxygen — Hudson River — July 7, 1911.

(Continued)

Sample No.	Hour a.m.	Location of samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen C.C. per li-tre	Oxygen Percent satura-tion
152	10.46	Off W.110th St. Midstream	Lat 40 48 32 Long 73 58 40	1	Ebb	25	78	5.27	91
153	10.47	Off W.110th St. Midstream	Lat 40 48 32 Long 73 58 40	20	Ebb	24.5	60	4.05	72
154	10.49	Off W.110th St. Midstream	Lat 40 48 32 Long 73 58 40	40	Ebb	24	52	4.05	72
155	11.11	Off W.129th St. Midstream	Lat 40 49 16 Long 73 58 10	1	Ebb	25	84	5.27	91
156	11.13	Off W.129th St. Midstream	Lat 40 49 16 Long 73 58 10	20	Ebb	24.5	68	4.05	72
157	11.14	Off W.129th St. Midstream	Lat 40 49 16 Long 73 58 10	35	Ebb	24.5	62	4.05	72
158	11.34	Off W.157th St. Midstream	Lat 40 50 21 Long 73 57 29	1	Ebb	25	84	5.27	91
159	11.35	Off W.157th St. Midstream	Lat 40 50 21 Long 73 57 29	20	Ebb	24.5	72	3.74	67
160	11.37	Off W.157th St. Midstream	Lat 40 50 21 Long 73 57 29	35	Ebb	24	63	3.74	67
161	11.57	Off Fort Washington Point, Midstream	Lat 40 51 04 Long 73 57 13	1	Ebb	25	84	5.61	97
162	11.58	Off Fort Washington Point, Midstream	Lat 40 51 04 Long 73 57 13	20	Ebb	24.5	72	3.74	67
163	12.00 p.m.	Off Fort Washington Point, Midstream	Lat 40 51 04 Long 73 57 13	35	Ebb	24	66	3.43	61
164	12.20	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	1	Ebb	25	88	5.61	97
165	12.21	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	20	Ebb	24.5	76	3.74	67
166	12.23	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	35	Ebb	24	68	3.43	61

Dissolved Oxygen. Hudson River July 7, 1911.

(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
167	12.43	Off Spuyten Duyvil-midstream	Lat 40 52 50 Long 73 56 04	1	Ebb	25	88	5.61	97
168	12.44	Off Spuyten Duyvil-midstream	Lat 40 52 50 Long 73 56 04	20	Ebb	24.5	76	4.33	77
169	12.46	Off Spuyten Duyvil-midstream	Lat 40 52 50 Long 73 56 04	30	Ebb	24.5	70	4.05	72
170	1.06	Off Riverdale-midstream	Lat 40 54 10 Long 73 55 25	1	Ebb	26	92	5.61	97
171	1.07	Off Riverdale-midstream	Lat 40 54 10 Long 73 55 25	20	Ebb	25	76	4.67	83
172	1.09	Off Riverdale-midstream	Lat 40 54 10 Long 73 55 25	30	Ebb	24.5	72	4.67	83
173	1.29	Off Mt.St.Vincent-midstream	Lat 40 54 50 Long 73 55 15	1	Ebb	26	92	5.61	97
174	1.30	Off Mt.St.Vincent-midstream	Lat 40 54 50 Long 73 55 15	20	Ebb	25	80	4.67	83
175	1.32	Off Mt.St.Vincent-midstream	Lat 40 54 50 Long 73 55 15	30	Ebb	24.5	76	4.67	83
176	1.52	Off Federal Sugar Refinery-Yonkers-midstream	Lat 40 55 47 Long 73 54 53	1	Ebb	26	92	5.61	97
177	1.53	Off Federal Sugar Refinery-Yonkers-midstream	Lat 40 55 47 Long 73 54 53	20	Ebb	25	76	4.67	83
178	1.55	Off Federal Sugar Refinery-Yonkers-midstream	Lat 40 55 47 Long 73 54 53	30	Ebb	24.5	74	4.73	85
179	2.15	Off Power-House-northern end of Yonkers-midstream	Lat 40 56 55 Long 73 54 35	1	End of Ebb	26	94	5.76	99
180	2.16	Off Power House-northern end of Yonkers-midstream	Lat 40 56 55 Long 73 54 35	20	"	25	76	4.67	83
181	2.18	Off Power House-northern end of Yonkers-midstream	Lat 40 56 55 Long 73 54 35	30	"	24.5	74	4.67	83

Dissolved Oxygen — Harlem River — July 10, 1911

High water at Governors Island at 7.43 a. m. Low water at 1.27 p. m

High water at Hell Gate at 9.30 a. m. Low water at 3.10 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
182	12.00	Off East 109th St-midstream	Lat 40 47 23 Long 73 54 07	1	Ebb	23.5	34	1.80	24
183	12.01	Off East 109th St-midstream	Lat 40 47 23 Long 73 54 07	15	Ebb	24	32	1.80	24
184	12.15	Willis Ave Bridge-midstream	Lat 40 48 12 Long 73 55 47	1	Ebb	23.5	32	1.87	25
185	12.16	Willis Ave Bridge-midstream	Lat 40 48 12 Long 73 55 47	15	Ebb	24	32	1.87	25
186	12.30	3d Ave Bridge-midstream	Lat 40 48 22 Long 73 55 59	1	Ebb	24	32	1.87	25
187	12.31	3d Ave Bridge-midstream	Lat 40 48 25 Long 73 55 59	15	Ebb	24	32	1.87	25
188	12.45	4th Ave Bridge-midstream	Lat 40 48 36 Long 73 56 02	1	Ebb	24	32	1.87	25
189	12.46	4th Ave Bridge-midstream	Lat 40 48 36 Long 73 56 02	15	Ebb	24	32	1.87	25
190	1.00	Madison Ave Bridge-midstream	Lat 40 49 49 Long 73 56 01	1	Ebb	24	32	1.87	25
191	1.01	Madison Ave Bridge-midstream	Lat 40 49 49 Long 73 56 01	15	Ebb	24	32	1.87	25
192	1.15	145th St.Bridge-midstream	Lat 40 49 10 Long 73 56 00	1	Ebb	24	32	1.87	25
193	1.16	145 St.Bridge-midstream	Lat 40 49 10 Long 73 56 00	15	Ebb	24	32	1.87	25

Dissolved Oxygen — Harlem River — July 10, 1911

(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percentage saturation
194	1.30	Central Bridge-midstream	Lat 40 49 40 Long 73 56 03	1	Ebb	24	32	1.87	35
195	1.31	Central Bridge-midstream	Lat 40 49 40 Long 73 56 03	15	Ebb	24	32	1.87	35
196	1.45	High Bridge-midstream	Lat 40 50 33 Long 73 55 51	1	Ebb	24	32	2.16	40
197	1.46	High Bridge-midstream	Lat 40 50 33 Long 73 55 51	15	Ebb	24	32	2.16	40
198	2.00	207 St.Bridge-midstream	Lat 40 51 46 Long 73 54 54	1	Ebb	24	32	2.49	46
199	2.01	207 St.Bridge-midstream	Lat 40 51 46 Long 73 54 54	15	Ebb	24	32	2.49	46
200	2.15	Kingsbridge-midstream	Lat 40 52 25 Long 73 54 39	1	Ebb	24	32	2.49	46
201	2.16	Kingsbridge-midstream	Lat 40 52 25 Long 73 54 39	15	Ebb	24	32	2.49	46
202	2.30	100' east of Spuyten Duyvil bridge	Lat 40 52 42 Long 73 55 29	1	Ebb	24	34	2.80	52
203	2.31	100' east of Spuyten Duyvil bridge	Lat 40 52 42 Long 73 55 29	15	Ebb	24	34	2.80	52

Dissolved Oxygen — Harlem River — July 10, 1911

Low water at Governors Island at 1.27 p. m.

Sample No.	Hour p.m.	Location of Sample: Approximate	Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
204	3.00	100' east of Spuyten Duyvil bridge	Lat 40	52	42	1	Flood	24.0	80	3.27	38
			Long 73	56	29						
205	3.01	100' east of Spuyten Duyvil bridge	Lat 40	52	42	15	Flood	24	76	3.27	38
			Long 73	56	29						
206	3.15	Kingsbridge-midstream	Lat 40	52	28	1	Flood	22	72	4.33	50
			Long 73	54	39						
207	3.16	Kingsbridge-midstream	Lat 40	52	25	15	Flood	24	72	4.33	50
			Long 73	54	39						
208	3.30	207 St.bridge-midstream	Lat 40	51	44	1	Flood	26	64	3.74	70
			Long 73	54	54						
209	3.31	207 St.bridge-midstream	Lat 40	51	44	15	Flood	22.5	64	3.74	70
			Long 73	54	54						
210	3.45	Highbridge-midstream	Lat 40	50	28	1	Flood	23.5	56	3.43	64
			Long 73	55	51						
211	3.46	Highbridge-midstream	Lat 40	50	25	15	Flood	23.5	56	3.43	64
			Long 73	55	51						
212	4.00	Central bridge-midstream	Lat 40	49	40	1	Flood	23.5	52	3.11	58
			Long 73	56	08						
213	4.01	Central bridge-midstream	Lat 40	49	40	15	Flood	23.5	52	3.11	58
			Long 73	56	08						
214	4.15	145 St.Bridge-midstream	Lat 40	49	10	1	Flood	23.5	46	2.80	53
			Long 73	56	00						
215	4.16	145 St.Bridge-midstream	Lat 40	49	10	15	Flood	23.5		2.80	53
			Long 73	56	00						
216	4.30	Madison Ave Bridge-midstream	Lat 40	48	49	1	Flood	23.5	40	2.49	47
			Long 73	56	01						
217	4.31	Madison Ave Bridge-midstream	Lat 40	48	49	15	Flood	23.5	40	2.49	47
			Long 73	56	01						

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1916

Dissolved Oxygen — Harlem River — July 10, 1911

(Continued)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
			°	'	"						
218	4.45	4th Ave Bridge-midstream	Lat 40	49	36	1	Flood	28.8	40	2.10	41
			Long 73	54	02						
219	4.46	4th Ave Bridge-midstream	Lat 40	49	36	18	Flood	28.8	40	2.18	41
			Long 73	54	02						
220	5.00	5th Ave Bridge-midstream	Lat 40	49	25	1	Flood	28.3	20	1.87	36
			Long 73	55	59						
221	5.01	5th Ave Bridge-midstream	Lat 40	49	25	18	Flood	28.5	40	1.87	36
			Long 73	55	59						
222	5.15	Willis Ave Bridge-midstream	Lat 40	49	18	1	Flood	28.5	36	1.50	29
			Long 73	56	47						
223	5.16	Willis Ave Bridge-midstream	Lat 40	49	18	18	Flood	28.0	36	1.50	28
			Long 73	56	47						
224	5.30	Foot of East 109 St-midstream	Lat 40	47	33	1	Flood	28.2	34	1.34	26
			Long 73	56	07						
225	5.31	Foot of East 109 St-midstream	Lat 40	47	33	18	Flood	28.7	34	1.34	26
			Long 73	56	07						

Rm. 94. p.80

Printed by BYRNE & CO., 521 W. 23rd St., New York.

Dissolved Oxygen — Buttermilk Channel — July 11, 1911

High water at Governors Island at 8.13 a.m. Low water at 2.06 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Per-cent land water	Oxygen C.C. per li-tre	Oxygen Percent satura-tion
226	9.50	Inner end of slip foot of De-Graw St, Brooklyn	Lat 40 41 13 Long 74 00 25	1	Ebb	26	38	0.31	6
227	9.52	Inner end of slip foot of De-Graw St, Brooklyn	Lat 40 41 13 Long 74 00 25	10	Ebb	25.5	34	0.31	6
228	10.07	Outer end of DeGraw St.Slip	Lat 40 41 14 Long 74 00 29	1	Ebb	25.5	38	0.62	12
229	10.09	Outer end of DeGraw St.slip	Lat 40 41 14 Long 74 00 29	20	Ebb	25.5	34	1.87	36
230	10.29	100 feet off outer end of DeGraw St.slip	Lat 40 41 14 Long 74 00 31	1	Ebb	25.5	36	0.93	18
231	10.30	100 feet off outer end of DeGraw St.slip	Lat 40 41 14 Long 74 00 31	20	Ebb	25.5	34	2.80	54
232	10.31	100 feet off outer end of DeGraw St.slip	Lat 40 41 14 Long 74 00 31	30	Ebb	25.5	34	3.11	60
233	10.50	200 feet off outer end of DeGraw St.slip	Lat 40 41 15 Long 74 00 32	1	Ebb	25.5	36	3.11	60
234	10.51	200 feet off outer end of DeGraw St.slip	Lat 40 41 15 Long 74 00 32	20	Ebb	25.5	34	3.11	60
235	10.53	200 feet off outer end of DeGraw St.slip	Lat 40 41 15 Long 74 00 32	35	Ebb	25.5	34	3.11	60
236	11.12	Inner end of slip east of Pier 32	Lat 40 41 14 Long 74 00 23	1	Ebb	26	36	0.31	6
237	11.14	Inner end of slip east of Pier 32	Lat 40 41 14 Long 74 00 23	10	Ebb	25.5	34	0.93	18
238	11.19	Outer end of slip east of Pier 32	Lat 40 41 16 Long 74 00 28	1	Ebb	26	36	0.62	12
239	11.20	Outer end of slip east of Pier 32	Lat 40 41 16 Long 74 00 28	15	Ebb	25.5	34	1.87	36
240	11.35	200 feet off Pier 29	Lat 40 41 22 Long 74 00 26	1	Ebb	25.5	34	3.11	60
241	11.37	200 feet off Pier 29	Lat 40 41 22 Long 74 00 26	20	Ebb	25.5	34	3.43	66

Dissolved Oxygen — Buttermilk Channel — July 11, 1911

(Continued)

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
242	11.39	200 feet off Pier 29	Lat 40 41 22 Long 74 00 26	35	Ebb	25.5	34	3.43	66
243	11.50	Outer end of slip west of Pier 29	Lat 40 41 19 Long 74 00 25	1	Ebb	26	34	2.49	50
244	11.51	Outer end of slip west of Pier 29	Lat 40 41 19 Long 74 00 25	20	Ebb	25.5	34	2.49	50
245	12.06	Inner end of slip west of Pier 29	Lat 40 41 18 Long 74 00 18	1	Ebb	26	34	1.50	30
246	12.08	Inner end of slip west of Pier 29 end	Lat 40 41 18 Long 74 00 18	10	Ebb	26	34	1.87	36
247	12.23	100 feet off east of Pier 33	Lat 40 41 10 Long 74 00 34	1	Ebb	25.5	34	2.18	40
248	12.24	100 feet off east end of Pier 33	Lat 40 41 10 Long 74 00 34	20	Ebb	25.5	34	2.80	54
249	12.26	100 feet off east end of Pier 33	Lat 40 41 10 Long 74 00 34	30	Ebb	25.5	34	2.80	54
250	12.45	200 feet off east end of Pier 33	Lat 40 41 11 Long 74 00 35	1	Ebb	25.5	34	3.11	60
251	12.46	200 feet off east end of Pier 33	Lat 40 41 11 Long 74 00 35	20	Ebb	25.5	34	3.11	60
252	12.48	200 feet off east end of Pier 33	Lat 40 41 11 Long 74 00 35	35	Ebb	25.5	34	3.11	60
253	1.18	200 feet off west end of Pier 33	Lat 40 41 04 Long 74 00 46	1	Ebb	25.5	34	3.11	60
254	1.19	200 feet off west end of pier 33	Lat 40 41 04 Long 74 00 46	20	Ebb	25.5	34	3.43	66
255	1.21	200 feet off west end of Pier 33	Lat 40 41 04 Long 74 00 46	35	Ebb	25.5	34	3.43	66
256	1.40	Entrance to Atlantic Basin	Lat 40 41 01 Long 74 00 45	1	Ebb	25.5	34	2.18	40
257	1.42	Entrance to Atlantic Basin	Lat 40 41 01 Long 74 00 45	20	Ebb	25.5	34	2.49	50

Dissolved Oxygen. Buttermilk Channel July 11, 1911. (Continued.)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact: o ' "	Feet below surface	Tidal current	Temp. water Deg C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
258	1.57	South side of Atlantic Basin Bowne St.	Lat 40 40 59 Long 74 00 33	1	Ebb	26	34	1.24	24
259	1.58	" " " " "	Lat 40 40 59 Long 74 00 33	15	Ebb	26	34	1.24	24
260	2.15	Upper bay-400 feet off Pier 39	Lat 40 40 42 Long 74 01 18	1	Ebb	25.5	34	2.80	54
261	2.16	" " " " " "	Lat 40 40 42 Long 74 01 18	30	Ebb	25.5	34	3.43	66
262	2.30	Upper bay-600 feet off Pier 39	Lat 40 40 42 Long 74 01 20	1	Ebb	25.5	34	3.43	66
263	2.31	" " " " " "	Lat 40 40 42 Long 74 01 20	30	Ebb	25.5	34	3.43	66
264	2.45	Upper bay-400 feet off Erie Basin entrance	Lat 40 40 19 Long 74 01 15	1	Ebb	25.5	34	3.11	60
265	2.46	" " " " " "	Lat 40 40 19 Long 74 01 15	30	Ebb	25.5	34	3.43	66
266	3.00	Upper bay-600 feet off Erie Basin entrance	Lat 40 40 19 Long 74 01 17	1	Ebb	25.5	34	3.43	66
267	3.01	" " " " " "	Lat 40 40 19 Long 74 01 17	30	Ebb	25.5	34	3.43	66
268	3.15	Upper bay-500 feet off 53d St., Brooklyn	Lat 40 39 10 Long 74 01 37	1	Ebb	25.5	34	3.43	66
269	3.16	" " " " "	Lat 40 39 10 Long 74 01 37	30	Ebb	25.5	34	3.43	66
270	3.30	Gowanus bay-near anchorage buoy	Lat 40 39 45 Long 74 01 20	1	Flood	25.5	32	3.43	66
271	3.31	" " " "	Lat 40 39 45 Long 74 01 20	30	Flood	25.5	34	3.43	66

Dissolved Oxygen — Hudson River — July 12, 1911

High water occurred at Governors Island at 8:53 a. m. Low water occurred at 2:47 p. m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. Water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
272	9.30	East River-midway between Battery and Governors Is.	Lat	40 41 52		1	Flood	24.5	32	3.11	59
			Long	74 00 59							
273	9.31	" "	Lat	40 41 52		20	Flood	24.5	32	3.43	66
			Long	74 00 59							
274	9.33	" "	Lat	40 41 52		35	Flood	24.5	32	3.43	65
			Long	74 00 59							
275	10.00	Hudson River-Battery to Yonkers. Midway between Pier A and C.R.R.of N.J.	Lat	40 42 19		1	Flood	24.5	32	3.43	65
			Long	74 01 34							
276	10.01	" "	Lat	40 42 19		20	Flood	24.5	32	3.43	65
			Long	74 01 34							
277	10.03	Note-Flood currents still running.	Lat	40 42 19		40	Flood	24.5	32	3.43	65
			Long	74 01 34							
278	11.00	Midway between Pier A and C.R.R. of N.J.	Lat	40 42 19		1	Ebb	25.5	40	3.43	65
			Long	74 01 34							
279	11.01	" "	Lat	40 42 19		20	Ebb	25.	32	3.43	66
			Long	74 01 34							
280	11.03	" "	Lat	40 42 19		40	Ebb	25.	32	3.43	66
			Long	74 01 34							
281	11.20	Off Canal St. Midstream	Lat	40 43 38		1	Ebb	25.5	44	3.43	65
			Long	74 01 17							
282	11.21	" "	Lat	40 43 38		20	Ebb	25.	46	3.43	66
			Long	74 01 17							
283	11.23	" "	Lat	40 43 38		40	Ebb	25.	46	3.43	66
			Long	74 01 17							
284	11.40	Off West 224 St. Midstream	Lat	40 45 09		1	Ebb	25.5	48	3.43	65
			Long	74 01 00							
285	11.41	" "	Lat	40 45 09		20	Ebb	25.	36	3.43	66
			Long	74 01 00							

Dissolved Oxygen — Hudson River — July 12, 1911

High water occurred at Governors Island at 8.53 a.m. Low water occurred at 2.47 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Location of Samples: Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
286	11.43	Off West 23 St. Midstream	Lat 40 45 09 Long 74 01 00	40	Ebb	25.	36	3.43	66
287	12.00 p.m.	Off West 42 St. Midstream	Lat 40 45 50 Long 74 00 38	1	Ebb	25.5	52	3.74	69
288	12.01	Off West 42 St. Midstream	Lat 40 45 50 Long 74 00 38	20	Ebb	25.	40	3.43	65
289	12.03	Off West 42 St. Midstream	Lat 40 45 50 Long 74 00 38	40	Ebb	25.	40	3.43	65
290	12.20	Off West 72 St. Midstream	Lat 40 47 02 Long 73 59 42	1	Ebb	25.5	52	4.05	75
291	12.21	Off West 72 St. Midstream	Lat 40 47 02 Long 73 59 42	20	Ebb	25.	40	3.74	70
292	12.23	Off West 72 St. Midstream	Lat 40 47 02 Long 73 59 42	40	Ebb	25.	40	3.74	70
293	12.40	Off West 110 St. Midstream	Lat 40 48 32 Long 73 58 40	1	Ebb	25.5	56	4.67	86
294	12.41	Off West 110 St. Midstream	Lat 40 48 32 Long 73 58 40	20	Ebb	25.	44	3.74	70
295	12.43	Off West 110 St. Midstream	Lat 40 48 32 Long 73 58 40	40	Ebb	25.	44	3.74	70
296	1.00	Off West 129 St. Midstream	Lat 40 49 16 Long 73 58 10	1	Ebb	25.5	64	5.27	96
297	1.01	Off West 129 St. Midstream	Lat 40 49 16 Long 73 58 10	20	Ebb	25.	48	4.06	75
298	1.03	Off West 129 St. Midstream	Lat 40 49 16 Long 73 58 10	35	Ebb	25.	48	4.05	75
299	1.30	Off West 157 St. Midstream	Lat 40 50 21 Long 73 57 29	1	Ebb	25.5	64	5.27	96

Dissolved Oxygen — Hudson River — July 18, 1911

High water occurred at Governors Island at 8.33 a.m. Low water occurred at 2.47 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
314	3.00	Off Mt. St. Vincent. Midstream	Lat 40 54 30 Long 73 56 15	1	Ebb	26.	90	5.61	100
315	3.01	Off Mt. St. Vincent. Midstream	Lat 40 54 30 Long 73 55 15	20	Ebb	25.5	64	4.25	80
316	3.03	Off Mt. St. Vincent. Midstream	Lat 40 54 30 Long 73 55 15	30	Ebb	25.5	64	4.25	80
317	3.20	Off Federal Sugar Refinery Yonkers midstream	Lat 40 55 47 Long 73 54 52	1	Ebb	26.	90	5.61	100
318	3.21	Off Federal Sugar Refinery Yonkers midstream	Lat 40 55 47 Long 73 54 53	20	Ebb	25.5	64	4.25	80
319	3.23	Off Federal Sugar Refinery Yonkers midstream	Lat 40 55 47 Long 73 54 53	30	Ebb	25.5	64	4.25	80
320	3.40	Off Power House, upper end of Yonkers, midstream	Lat 40 56 55 Long 73 54 35	1	Ebb	26.	90	5.61	100
321	3.41	Off Power House, upper end of Yonkers, midstream	Lat 40 56 55 Long 73 54 35	20	Ebb	25.5	64	4.25	80
322	3.43	Off Power House, upper end of Yonkers, midstream	Lat 40 56 55 Long 73 54 35	30	Ebb	25.5	64	4.25	80

Dissolved Oxygen — Hudson River — July 18, 1911.

High water occurred at Governors Island at 6.52 a.m. Low water at 3.47 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
300	1.21	Off West 187 St. Midstream	Lat 40 50 21 Long 73 57 39	20	Ebb	25.	48	4.08	78
301	1.29	Off West 187 St. Midstream	Lat 40 50 21 Long 73 57 29	35	Ebb	25.	48	4.08	78
302	1.40	Off Fort Washington Point. Midstream	Lat 40 51 04 Long 73 57 13	1	Ebb	26.	68	5.61	100
303	1.41	Off Fort Washington Point. Midstream	Lat 40 51 04 Long 73 57 13	20	Ebb	25.	48	4.08	78
304	1.48	Off Fort Washington Point, Midstream	Lat 40 51 04 Long 73 57 13	35	Ebb	25.	48	4.08	78
305	2.00	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	1	Ebb	26.	68	5.61	100
306	2.01	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	20	Ebb	25.	52	4.08	78
307	2.08	Off Inwood. Midstream	Lat 40 52 20 Long 73 56 24	35	Ebb	25.	52	4.08	78
308	2.20	Off Spuyten Duyvil. Midstream	Lat 40 52 50 Long 73 56 04	1	Ebb	26.	80	5.61	100
309	2.21	Off Spuyten Duyvil. Midstream	Lat 40 52 50 Long 73 56 04	20	Ebb	25.5	56	4.08	78
310	2.28	Off Spuyten Duyvil. Midstream	Lat 40 52 50 Long 73 56 04	30	Ebb	25.5	52	4.08	78
311	2.40	Off Riverdale. Midstream	Lat 40 54 10 Long 73 55 35	1	Ebb	26.	80	5.61	100
312	2.41	Off Riverdale. Midstream	Lat 40 54 10 Long 73 55 25	20	Ebb	25.5	60	4.23	80
313	2.48	Off Riverdale. Midstream	Lat 40 54 10 Long 73 55 25	30	Ebb	25.5	68	4.50	80

Dissolved Oxygen Buttermilk Channel, East River. July 13, 1911

High water occurred at Governors Island at 9.23 a.m. Low water occurred at 3.02 p.m.

Sample No.	Hour a.m.	Location of Samples		Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact o ' "	Feet below surface			C.C. per litre	Percent saturation
323	9.20	200' off outer end of De Graw St.slip	Lat 40 41 15 Long 74 00 32	1	Flood	25.5	32	3.11	60
324	9.21	200' off outer end of De Graw St.slip	Lat 40 41 15 Long 74 00 32	20	Flood	25.	32	3.11	60
325	9.23	200' off outer end of De Graw St.slip	Lat 40 41 15 Long 74 00 32	35	Flood	25.	32	3.11	60
326	9.28	50' off outer end of De Graw St.slip	Lat 40 41 14 Long 74 00 30	1	Flood	25.5	34	1.24	24
327	9.29	50' off outer end of De Graw St.slip	Lat 40 41 14 Long 74 00 30	20	Flood	25.	32	2.80	56
328	9.31	50' off outer end of De Graw St.slip	Lat 40 41 14 Long 74 00 30	30	Flood	25.	32	3.11	60
329	9.46	De Graw St.slip outer end	Lat 40 41 14 Long 74 00 29	1	Flood	26.	34	0.93	18
330	9.48	De Graw St.slip outer end	Lat 40 41 14 Long 74 00 29	20	Flood	25.5	34	2.18	42
331	10.02	De Graw St.slip inner end	Lat 40 41 13 Long 74 00 25	1	Flood	26.	34	0.47	9
332	10.04	De Graw St.slip inner end	Lat 40 41 13 Long 74 00 25	10	Flood	26.	34	0.62	12
333	10.20	200' off Pier 29	Lat 40 41 22 Long 74 00 26	1	Flood	25.5	34	3.11	60
334	10.21	200' off Pier 29	Lat 40 41 22 Long 74 00 26	20	Flood	25.	32	3.11	60
335	10.23	200' off Pier 29	Lat 40 41 22 Long 74 00 26	30	Flood	25.	32	3.11	60
336	10.40	50' off Pier 29, Brooklyn	Lat 40 41 21 Long 74 00 25	1	Flood	25.5	34	2.49	48
337	10.42	50' off Pier 29, Brooklyn	Lat 40 41 21 Long 74 00 25	30	Flood	25.	32	3.11	60

Dissolved Oxygen — Buttermilk Channel, East River. — July 18, 1911.

High water occurred at Governors Island at 9.23 a.m. Low water occurred at 3.02 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
338	10.57	Slip just west of Pier 29 midway up slip	Lat 40 41 18 Long 74 00 21	1	Flood	25.5	34	1.50	30
339	10.58	Slip just west of Pier 29 midway up slip	Lat 40 41 18 Long 74 00 21	15	Flood	25.	32	1.50	30
340	11.10	200' off east end of Pier 33	Lat 40 41 11 Long 74 00 35	1	Flood	25.5	34	3.74	72
341	11.11	200' off east end of Pier 33	Lat 40 41 11 Long 74 00 35	20	Flood	25.	32	3.74	72
342	11.13	200' off east end of Pier 33	Lat 40 41 11 Long 74 00 35	35	Flood	25.	32	3.74	72
343	11.30	50' off east end of Pier 33	Lat 40 41 10 Long 74 00 33	1	Flood	25.5	34	3.74	72
344	11.31	50' off east end of Pier 33	Lat 40 41 10 Long 74 00 33	20	Flood	25.	32	3.74	72
345	11.33	50' off east end of Pier 33	Lat 40 41 10 Long 74 00 33	35	Flood	25.	32	3.74	72
346	11.48	Entrance to Atlantic basin	Lat 40 41 01 Long 74 00 45	1	Ebb	25.5	34	3.74	72
347	11.50	South extremity of Atlantic Basin Bowne St.	Lat 40 40 59 Long 74 00 33	1	Ebb	25.5	34	1.24	24
348	11.51	South extremity of Atlantic Basin Bowne St.	Lat 40 40 59 Long 74 00 33	10	Ebb	25.5	34	1.24	24

Dissolved Oxygen Course from Governors Island to Atlantic Ocean. July 13, 1911.

High water occurred at Governors Island at 10.23 a.m. Low water at 4.27 p.m.

High water occurred at Sandy Hook at 8.50 a.m. Low water at 2.30 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
349	12.00	East River midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	1	Ebb	24.	32	3.11	59
350	12.01	East River midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	20	Ebb	24.	32	3.11	59
351	12.03	East River midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	35	Ebb	24.	32	3.11	59
352	12.20	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	1	Ebb	24.5	32	3.11	59
353	12.21	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	20	Ebb	24.	30	3.11	59
354	12.23	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	30	Ebb	24.	30	3.11	59
355	12.44	Upper bay-near Robbins Reef bell-buoy	Lat 40 39 15 Long 74 03 50	1	Ebb	24.5	34	3.43	65
356	12.45	Upper bay-near Robbins Reef Bell buoy	Lat 40 39 15 Long 74 03 50	20	Ebb	24.	32	3.43	65
357	12.47	Upper bay-near Robbins Reef bell buoy	Lat 40 39 15 Long 74 03 50	40	Ebb	24.	28	3.43	65
358	1.07	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	25.	26	3.43	66
359	1.09	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	40	Ebb	22.	20	3.43	64
360	1.12	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	80	Ebb	22.	20	3.43	64

Dissolved Oxygen Course from Governors Island to Atlantic Ocean. July 13, 1911

High water occurred at Governors Island at 10.25 a.m. Low water at 4.27 p.m.

High water occurred at Sandy Hook at 8.50 a.m. Low water at 2.30 p.m.

Sample No.	Hour p.m.	Location of Samples					Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact ° ' "			Feet below surface				C.C. per litre	Percent saturation
361	1.32	Lower bay by Craven shoal buoy	Lat	40	35 10	1	Ebb	23.	24	5.74	70
			Long	74	02 30						
362	1.33	Lower bay by Craven shoal buoy	Lat	40	35 10	20	Ebb	21.5	20	5.74	70
			Long	74	02 30						
363	1.35	Lower bay by Craven shoal buoy	Lat	40	35 10	40	Ebb	21.5	20	5.74	70
			Long	74	02 30						
364	2.00	Lower bay-Ambrose channel buoy 19	Lat	40	32 20	1	Ebb	23.	24	8.27	99
			Long	74	01 15						
365	2.01	Lower bay-Ambrose channel buoy 19	Lat	40	32 20	20	Ebb	21.5	20	8.27	99
			Long	74	01 15						
366	2.03	Lower bay-Ambrose channel buoy 19	Lat	40	32 20	40	Ebb	21.5	20	8.27	99
			Long	74	01 15						
367	2.30	Lower bay-Ambrose channel buoy 6	Lat	40	30 25	1	Ebb	21.	20	8.61	100
			Long	73	57 35						
368	2.31	Lower bay-Ambrose channel buoy 6	Lat	40	30 25	20	Ebb	20.	12	8.61	100
			Long	73	57 35						
369	2.33	Lower bay-Ambrose channel buoy 6	Lat	40	30 25	40	Ebb	20.	12	8.61	100
			Long	73	57 35						
370	3.00	Atlantic Ocean-east of whistling buoy outside Ambrose channel	Lat	40	29 00	1	Ebb	21.	19	8.61	100
			Long	73	53 00						
371	3.01	Atlantic Ocean-east of whistling buoy outside Ambrose Channel	Lat	40	29 00	25	Ebb	20.	12	8.61	100
			Long	73	53 00						
372	3.03	Atlantic Ocean-east of whistling buoy outside Ambrose Channel	Lat	40	29 00	50	Ebb	20.	12	8.61	100
			Long	73	53 00						

Ex. 94. p.31

Dissolved Oxygen Course from Governors Island to Atlantic Ocean. July 14, 1911.

High water occurred at Governors Island at 9.33 a.m. Low water at 4.07 p.m.

High water occurred at Sandy Hook at 9.23 a.m. Low water at 3.15 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
373	8.00	East River-midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	1	Flood	23.	30	3.43	62
374	8.01	East River-midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	20	Flood	22.	28	3.43	62
375	8.03	East River-midway between Governors Is. and pier 38, Brooklyn	Lat 40 40 53 Long 74 01 19	35	Flood	22.	28	3.43	62
376	8.20	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	1	Flood	23.	30	3.43	62
377	8.21	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	20	Flood	22.	28	3.43	62
378	8.23	Upper bay-near nun buoy 14 off Gowanus	Lat 40 40 04 Long 74 02 09	30	Flood	22.	28	3.43	62
379	8.40	Upper bay-near Robbins Reef bell buoy	Lat 40 39 15 Long 74 03 50	1	Flood	23.	30	3.74	68
380	8.41	Upper bay-near Robbins Reef bell buoy	Lat 40 39 15 Long 74 03 50	20	Flood	21.5	26	4.08	74
381	8.43	Upper bay-near Robbins Reef bell buoy	Lat 40 39 15 Long 74 03 50	40	Flood	21.5	24	4.08	74
382	9.15	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	1	Flood	23.	26	4.33	79
383	9.16	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	40	Flood	21.5	24	4.67	85
384	9.18	Narrows-midway between forts	Lat 40 36 25 Long 74 02 48	80	Flood	21.5	24	4.67	85

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY.

Dissolved Oxygen Course from Governors Island to Atlantic Ocean. July 14, 1911

High water occurred at Governors Island at 7.23 a.m. Low water at 6.09 p.m.

High water occurred at Sandy Hook at 9.29 a.m. Low water at 3.15 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	'	"	Just below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
388	9.26	Lower bay, near Craven Shoal buoy	Lat	40	28	10	1	Flood	22.	24	5.01	93
			Long	74	02	50						
386	9.27	Lower bay, near Craven Shoal buoy	Lat	40	28	10	20	Flood	21.8	24	5.01	93
			Long	74	02	50						
387	9.29	Lower bay, near Craven Shoal buoy	Lat	40	28	10	40	Flood	21.8	22	5.01	93
			Long	74	02	50						
389	9.50	Lower bay, near Ambrose channel buoy	Lat	40	30	25	1	Flood	20	14	5.61	97
			Long	73	57	38						
389	9.51	Lower bay, near Ambrose channel buoy	Lat	40	30	25	20	Flood	19	12	5.61	100
			Long	73	57	38						
390	9.52	Lower bay, near Ambrose channel buoy	Lat	40	30	25	40	Flood	19	12	5.61	100
			Long	73	57	38						
391	10.10	Lower bay, near Ambrose channel buoy	Lat	40	30	25	1	Flood	20	16	5.76	100
			Long	73	57	38						
392	10.11	Lower bay, near Ambrose channel buoy	Lat	40	30	25	20	Flood	18.8	12	5.61	100
			Long	73	57	38						
393	10.12	Lower bay, near Ambrose channel buoy	Lat	40	30	25	40	Flood	18.8	12	5.61	100
			Long	73	57	38						
394	10.48	Lower bay, near Ambrose channel buoy	Lat	40	30	25	1	Flood	17	12	5.76	100
			Long	73	57	38						
395	10.46	Lower bay, near Ambrose channel buoy	Lat	40	30	25	20	Flood	16	8	5.76	100
			Long	73	57	38						
396	10.48	Lower bay, near Ambrose channel buoy	Lat	40	30	25	40	Flood	16	8	5.76	100
			Long	73	57	38						
397	11.20	Atlantic Ocean, midway between Ambrose channel buoy 2 and whistling buoy further out	Lat	40	28	20	1	End of Flood	17	10	5.76	100
			Long	73	51	40						

Dissolved Oxygen Course from Governors Island to Atlantic Ocean July 14, 1911.

High water occurred at Governors Island at 9.55 a.m. Low water at 4.07 p.m.

High water occurred at Sandy Hook at 9.53 a.m. Low water at 5.15 p.m.

Sample No.	Hour a.m.	Location of Samples				Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percentage tion
		Approximate									
898	11.20	Atlantic Ocean, midway between Ambrose channel buoy 2 and whistling buoy further out	lat	40	28 30	20	End of Flood	16	0	8.96	100
			Long	73	51 40						
899	11.28	Atlantic Ocean, midway between Ambrose channel buoy 2 and whistling buoy further out	lat	40	28 30	40	End of Flood	15.8	0	8.96	100
			Long	73	51 40						

Ex. 94. p.34

Dissolved Oxygen — Kill van Kull — July 17th, 1911.

High water occurred at Governors Island at 12.08 a.m. Low water at 6.27 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: Lat o ' "	Long o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
400	10.40	Upper New York bay, near Robbins Reef bell buoy	Lat 40 39 15	Long 74 03 50	1	Flood	23	30	3.74	68
401	10.41	Upper New York bay, near Robbins Reef bell buoy	Lat 40 39 15	Long 74 03 50	20	Flood	22	24	3.74	68
402	10.43	Upper New York bay, near Robbins Reef bell buoy	Lat 40 39 15	Long 74 03 50	40	Flood	22	24	3.74	68
403	11.00	Kill van Kull off Jersey St. New Brighton, S.I. midstream	Lat 40 38 57	Long 74 06 25	1	Flood	23	32	3.43	62
404	11.01	Kill van Kull off Jersey St. New Brighton, S.I. Midstream	Lat 40 38 57	Long 74 06 25	20	Flood	22	24	3.74	68
405	11.03	Kill van Kull off Jersey St. New Brighton, S.I. midstream	Lat 40 38 57	Long 74 06 25	40	Flood	22	24	3.74	68
406	11.20	Kill van Kull off Sailors Snug Harbor, midstream	Lat 40 38 50	Long 74 06 07	1	Flood	23	32	3.43	62
407	11.21	Kill van Kull off Sailors Snug Harbor, midstream	Lat 40 38 50	Long 74 06 07	20	Flood	22	28	3.74	68
408	11.23	Kill van Kull off Sailors Snug Harbor, midstream	Lat 40 38 50	Long 74 06 07	35	Flood	22	28	3.74	68
409	11.40	Kill van Kull off Port Richmond ferry, midstream	Lat 40 38 35	Long 74 07 52	1	Flood	23	32	3.43	62
410	11.41	Kill van Kull off Port Richmond ferry, midstream	Lat 40 38 35	Long 74 07 52	20	Flood	22	28	3.74	68

Dissolved Oxygen Kill van Kull July 17, 1911.

High water occurred at Governors Island at 12.08 a.m. Low water at 6.27 p.m.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp. water Deg.C.	Percent land water	Oxygen	
		Approximate	Exact o ' "	Feet below surface				C.C. per litre	Percent saturation
411	11.43	Kill van Kull off Port Richmond ferry, midstream	Lat 40 38 25 Long 74 07 52	40	Flood	22	28	3.74	68
412	12.00	Kill van Kull at buoy S 2 off Bergen Pt. midstream	Lat 40 38 35 Long 74 08 24	1	Flood	23	32	3.43	62
	12.01 p.m.	Kill van Kull at buoy S 2 off Bergen Pt. midstream	Lat 40 38 35 Long 74 08 24	20	Flood	22	30	3.43	62
414	12.03	Kill van Kull at buoy S 2 off Bergen Pt. midstream	Lat 40 38 35 Long 74 08 24	40	Flood	22	30	3.43	62
415	12.20	Kill van Kull-100' south of Bergen Pt. light	Lat 40 38 32 Long 74 08 56	1	Flood	23	32	3.43	62
416	12.21	Kill van Kull-100' south of Bergen Pt. light	Lat 40 38 32 Long 74 08 56	20	Flood	22	30	3.43	62
417	12.23	Kill van Kull-100' south of Bergen Pt. light	Lat 40 38 32 Long 74 08 56	30	Flood	22	30	3.43	62

Dissolved Oxygen East River, Cross-section-Lawrence Point to Stony Point. July 18, 1911.

High water occurred at Governors Island at 12.53 p.m. Low water at 7.17 a.m.

High water occurred at Hell Gate at 3.30 p.m. Low water at 9. a.m.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact o ' "	Feet below surface				C.C. per litre	Percent saturation
418	10.10	By buoy 7, near Lawrence Point, Astoria	Lat 40 47 34 Long 73 54 30	1	Flood	21.5	24	3.24	59
419	10.11	By buoy 7, near Lawrence Point, Astoria	Lat 40 47 34 Long 73 54 30	20	Flood	21	24	3.24	59
420	10.13	By buoy 7, near Lawrence Point, Astoria	Lat 40 47 34 Long 73 54 30	40	Flood	21	24	3.24	59
421	10.23	Midway between Lawrence Point and Stony Point	Lat 40 47 45 Long 73 54 31	1	Flood	21.5	24	3.24	59
422	10.24	Midway between Lawrence Point and Stony Point	Lat 40 47 45 Long 73 54 31	25	Flood	21	24	3.24	59
423	10.26	Midway between Lawrence Point and Stony Point	Lat 40 47 45 Long 73 54 31	50	Flood	21	24	3.24	59
424	10.45	200' off East 134 St. ferry house at Stony Point	Lat 40 47 56 Long 73 54 31	1	Flood	21.5	24	3.24	59
425	10.46	200' off East 134 St. ferry house at Stony Point	Lat 40 47 56 Long 73 54 31	25	Flood	21	24	3.24	59
426	10.48	200' off East 134 St. ferry house at Stony Point	Lat 40 47 56 Long 73 54 31	50	Flood	21	24	3.24	59
427	11.30	By buoy 7, near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	1	Flood	21.5	28	3.09	56
428	11.31	By buoy 7, near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	20	Flood	21	26	3.09	56
429	11.33	By buoy 7, near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	40	Flood	21	26	3.09	56

Dissolved Oxygen East River, Cross-section-Lawrence Point to Stony Point. July 28, 1911

High water occurred at Governors Island at 12.83 p.m. Low water at 7.17 a.m.

High water occurred at Hell Gate at 3.30 p.m. Low water at 9. a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact:	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
430	11.53	Midway between Lawrence and Stony Points	Lat	40	47	45	1	Flood	21.5	28	3.09	56
			Long	73	54	31						
431	11.54	Midway between Lawrence and Stony Points	Lat	40	47	45	25	Flood	21	26	3.09	56
			Long	73	54	31						
432	11.56	Midway between Lawrence and Stony Points	Lat	40	47	45	50	Flood	21	26	3.09	56
			Long	73	54	31						
433	12.17 p.m.	200' off E. 134 St. ferry house	Lat	40	47	56	1	Flood	21.5	28	3.09	56
			Long	73	54	31						
434	12.18	200' off E. 134 St. ferry house	Lat	40	47	56	25	Flood	21	26	3.09	56
			Long	73	54	31						
435	12.20	200' off E. 134 St. ferry house	Lat	40	47	56	50	Flood	21	26	3.24	59
			Long	73	54	31						
436	1.	By buoy 7 near Lawrence Point	Lat	40	47	34	1	Flood	21.5	30	2.95	54
			Long	73	54	30						
437	1.01	By buoy 7 near Lawrence Pt.	Lat	40	47	34	20	Flood	21	28	2.95	54
			Long	73	54	30						
438	10.3	By buoy 7 near Lawrence Pt.	Lat	40	47	34	40	Flood	21	28	2.95	54
			Long	73	54	30						
439	1.23	Midway between Lawrence and Stony Points	Lat	40	47	45	1	Flood	21.5	30	2.95	54
			Long	73	54	31						
440	1.24	Midway between Lawrence and Stony Points	Lat	40	47	45	20	Flood	21	28	2.95	54
			Long	73	54	31						
441	1.26	Midway between Lawrence and Stony Points	Lat	40	47	45	50	Flood	21	28	3.09	56
			Long	73	54	31						
442	1.46	200' off E. 134 St. ferry house	Lat	40	47	56	1	Flood	21.5	30	2.95	54
			Long	73	54	31						
443	1.47	200' off E. 134 St. ferry house	Lat	40	47	56	25	Flood	21	28	2.95	54
			Long	73	54	31						

Dissolved Oxygen East River, Cross-section-Lawrence Point to Stony Point. July 18, 1911

High water occurred at Governors Island at 12.53 p.m. Low water at 7.17 a.m.

High water occurred at Hell Gate at 3.30 p.m. Low water at 9. a.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
444	1.49	200 off E. 134 St. ferry house	Lat 40 47 56 Long 73 54 31	50	Flood	21	28	3.09	86
445	2.30	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	1	Flood	21.5	30	2.95	84
446	2.31	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	20	Flood	21	28	2.95	84
447	2.33	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	40	Flood	21	28	2.95	84
448	2.50	Midway between Laurence Point and Stony Point	Lat 40 47 45 Long 73 54 31	1	Flood	21.5	30	2.95	84
449	2.51	Midway between Lawrence Point and Stony Point	Lat 40 47 45 Long 73 54 31	25	Flood	21	28	2.95	84
450	2.53	Midway between Lawrence and Stony Points	Lat 40 47 45 Long 73 54 31	50	Flood	21	28	2.95	84
451	3.10	200' off E. 134 St. ferry house	Lat 40 47 56 Long 73 54 31	1	Flood	21.5	30	2.95	84
452	3.11	200' off E. 134 St. ferry house	Lat 40 47 56 Long 73 54 31	25	Flood	21	28	2.95	84
453	3.13	200' off E. 134 St. ferry house	Lat 40 47 56 Long 73 54 31	50	Flood	21	28	2.95	84
454	3.30	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	1	Flood	21.5	30	2.95	84
455	3.31	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	20	Flood	21	28	2.95	84
456	3.33	By buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	40	Flood	21	28	2.95	84
457	3.45	Midway between Lawrence and Stony Points	Lat 40 47 45 Long 73 54 31	1	Flood	21.5	30	2.95	84

Dissolved Oxygen. East River. Cross-section-Lawrence Point to Stony Point. July 10, 1911.

High water occurred at Governors Island at 12.58 p.m. Low water at 7.17 a.m.

High water occurred at Hell Gate at 2.30 p.m. Low water at 9. a.m.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact ° ' "	Feet below surface				C.C. per litre	Percent saturation
458	3.44	Midway between Lawrence and Stony Points	Lat 40 47 48 Long 73 84 31	25	Flood	21	38	3.98	84
459	3.48	Midway between Lawrence and Stony Points	Lat 40 47 48 Long 73 84 31	50	Flood	21	38	3.98	84
460	4.00	200' off E.134 St.ferry house	Lat 40 47 56 Long 73 84 31	1	Flood	21.5	30	3.98	84
461	4.01	200' off E.134 St.ferry house	Lat 40 47 56 Long 73 84 31	25	Flood	21	36	3.09	86
462	4.08	200' off E.134 St.ferry house	Lat 40 47 56 Long 73 84 31	50	Flood	21	36	3.09	86

Ex. 94. p.40

Dissolved Oxygen. Cross-section of Hudson River between Pier A Manhatten, and C.R.R. of N. J. Ferry house Jersey City. July 19, 1911.

High water occurred at Governors Island at 1.53 p.m. Low water at 7.27 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
463	9.15	200' off Pier A	Lat 40 42 16 Long 74 01 10	1	Ebb	23	42	3.09	35
464	9.16	200' " " "	Lat 40 42 16 Long 74 01 10	20	Ebb	23	39	2.95	33
465	9.18	200' " " "	Lat 40 42 16 Long 74 01 10	40	Ebb	23	36	2.95	33
466	9.30	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Ebb	23	42	3.09	35
467	9.31	" " " "	Lat 40 42 17 Long 74 01 20	20	Ebb	23	39	3.09	35
468	9.33	" " " "	Lat 40 42 17 Long 74 01 20	40	Ebb	23	36	3.09	35
469	9.45	Midstream	Lat 40 42 19 Long 74 01 34	1	Ebb	23	46	3.24	38
470	9.46	"	Lat 40 42 19 Long 74 01 34	20	Ebb	23	40	3.24	38
471	9.48	"	Lat 40 42 19 Long 74 01 34	40	Ebb	23	38	3.24	38
472	10.00	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Ebb	23	46	3.09	35
473	10.01	" " " "	Lat 40 42 21 Long 74 01 48	20	Ebb	23	40	3.24	38
474	10.03	" " " "	Lat 40 42 21 Long 74 01 48	38	Ebb	22	40	3.24	38
475	10.15	200' off C.R.R. of N.J. ferry house	Lat 40 42 22 Long 74 01 59	1	Ebb	23	48	3.09	35
476	10.16	" " " "	Lat 40 42 22 Long 74 01 59	20	Ebb	22	44	3.24	38
477	10.18	" " " "	Lat 40 42 22 Long 74 01 59	30	Ebb	23	44	3.24	38

Dissolved Oxygen. Hudson River Cross-section of Pier A, Manhattan to C.R.R. of N. J. ferry house, Jersey City. July 20, 1911.

High water occurred at Governors Island at 2.53 p.m. Low water at 8.27 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
478	9.15	100' off Pier A	Lat 40 42 16 Long 74 01 09	1	Ebb	23	40	2.95	53
479	9.16	" " " "	Lat 40 42 16 Long 74 01 09	20	Ebb	22	36	2.95	53
480	9.18	" " " "	Lat 40 42 16 Long 74 01 09	40	Ebb	22	36	2.95	53
481	9.23	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Ebb	23	40	3.00	54
482	9.24	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Ebb	22	36	3.00	54
483	9.26	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Ebb	22	36	3.00	54
484	9.33	Midstream	Lat 40 42 19 Long 74 01 34	1	Ebb	23	40	3.01	54
485	9.34	"	Lat 40 42 19 Long 74 01 34	20	Ebb	22	36	3.01	54
486	9.36	"	Lat 40 42 19 Long 74 01 34	40	Ebb	22	36	3.01	54
487	9.40	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Ebb	23	40	3.10	55
488	9.41	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Ebb	22	36	3.10	55
489	9.43	" " " " " "	Lat 40 42 21 Long 74 01 48	35	Ebb	22	36	3.10	55
490	9.46	100' off C.R.R. of N. J. ferry house	Lat 40 42 22 Long 74 01 59	1	Ebb	23	40	3.03	54
491	9.47	" " " " "	Lat 40 42 22 Long 74 01 59	20	Ebb	22	36	3.03	54
492	9.48	" " " " "	Lat 40 42 22 Long 74 01 59	30	Ebb	22	36	3.03	54

Dissolved Oxygen. Hudson River, Cross-section of Pier A, Manhattan to C. R. R. of N. J. ferry-house, Jersey City. (Continued) July 20, 1911.

Sample No.	Hour P.M.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent. satura-tion
493	12.15	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	1	Flood	23	40	3.09	55
494	12.16	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	20	Flood	22	36	3.09	55
495	12.18	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	40	Flood	22	36	3.09	55
496	12.23	¼ way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Flood	23	40	3.14	56
497	12.24	¼ way across from Pier A	Lat 40 42 17 Long 74 01 20	20	Flood	22	36	3.14	56
498	12.26	¼ way across from Pier A	Lat 40 42 17 Long 74 01 20	40	Flood	22	36	3.14	56
499	12.31	Midstream	Lat 40 42 19 Long 74 01 34	1	Flood	23	40	3.15	56
500	12.32	Midstream	Lat 40 42 19 Long 74 01 34	20	Flood	22	36	3.15	56
501	12.34	Midstream	Lat 40 42 19 Long 74 01 34	40	Flood	22	36	3.15	56
502	12.39	¾ way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Flood	23	40	3.24	58
503	12.40	¾ way across from Pier A	Lat 40 42 21 Long 74 01 48	20	Flood	22	36	3.24	58
504	12.42	¾ way across from Pier A	Lat 40 42 21 Long 74 01 48	35	Flood	22	36	3.24	58
505	12.47	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	1	Flood	23	40	3.17	57
506	12.48	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	20	Flood	22	36	3.17	57
507	12.50	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	30	Flood	22	36	3.17	57

Dissolved Oxygen. Hudson River, Cross-section of Pier A, Manhattan to C. R. R. of N. J. ferry-house, Jersey City. (continued) July 20, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
508	2.15	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	1	Flood	22	38	3.24	58
509	2.16	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	20	Flood	22	36	3.24	58
510	2.18	100' off Pier A, N.Y.	Lat 40 42 16 Long 74 01 09	40	Flood	22	36	3.24	58
511	2.22	¼ way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Flood	23	36	3.29	59
512	2.23	½ way across from Pier A	Lat 40 42 17 Long 74 01 20	20	Flood	22	32	3.29	59
513	2.25	¾ way across from Pier A	Lat 40 42 17 Long 74 01 20	40	Flood	22	32	3.29	59
514	2.30	Midstream	Lat 40 42 19 Long 74 01 34	1	Flood	23	38	3.29	59
515	2.31	Midstream	Lat 40 42 19 Long 74 01 34	20	Flood	22	30	3.29	59
516	2.33	Midstream	Lat 40 42 19 Long 74 01 34	40	Flood	22	30	3.29	59
517	2.38	¾ way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Flood	23	38	3.24	58
518	2.39	½ way across from Pier A	Lat 40 42 21 Long 74 01 48	20	Flood	22	30	3.24	58
519	2.41	¼ way across from Pier A	Lat 40 42 21 Long 74 01 48	35	Flood	22	30	3.24	58
520	2.46	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	1	Flood	23	38	3.17	57
521	2.47	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	20	Flood	22	30	3.17	57
533	2.49	100' off C.R.R. of N.J. ferry-house	Lat 40 42 22 Long 74 01 59	30	Flood	22	30	3.17	57

Dissolved Oxygen. East River. Cross-section of East River from Throgs Neck (landing west of light) to Whitestone landing. July 21, 1911.

High water occurred at Governors Island at 4.08 p.m. Low water at 9.42 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
525	11.20	300' off Throgs Neck	Lat 40 48 27 Long 73 48 16	1	Ebb	20	24	4.01	72
524	11.21	300' off Throgs Neck	Lat 40 48 27 Long 73 48 16	25	Ebb	19.5	22	4.00	71
525	11.23	300' off Throgs Neck	Lat 40 48 27 Long 73 48 16	40	Ebb	19.5	22	4.00	71
526	11.43	¼ way across from Throgs Neck.	Lat 40 48 20 Long 73 48 18	1	Ebb	20	24	4.01	72
527	11.44	¼ way across from Throgs Neck	Lat 40 48 20 Long 73 48 18	20	Ebb	19.5	22	4.00	71
528	11.46	¼ way across from Throgs Neck	Lat 40 48 20 Long 73 48 18	40	Ebb	19.5	22	4.00	71
529	12.20	Half-way across	Lat 40 48 09 Long 73 48 21	1	Ebb	20	24	4.01	72
530	12.21	Half-way across	Lat 40 48 09 Long 73 48 21	20	Ebb	19.5	22	4.00	71
531	12.23	Half-way across	Lat 40 48 09 Long 73 48 21	35	Ebb	19.5	22	4.00	71
532	12.42	¾ way across from Throgs Neck	Lat 40 47 58 Long 73 48 24	1	Ebb	20	24	4.01	72
533	12.44	¾ way across from Throgs Neck	Lat 40 47 58 Long 73 48 24	20	Ebb	19.5	22	4.00	71
534	12.46	¾ way across from Throgs Neck	Lat 40 47 58 Long 73 48 24	30	Ebb	19.5	22	4.00	71
535	1.10 p.m.	300' off Whitestone landing	Lat 40 47 50 Long 73 48 28	1	Ebb	20	24	4.01	72
536	1.11	300' off Whitestone landing	Lat 40 47 50 Long 73 48 28	20	Ebb	19.5	22	4.00	71
537	1.13	300' off Whitestone landing	Lat 40 47 50 Long 73 48 28	30	Ebb	19.5	22	4.00	71

Dissolved Oxygen. Hudson River from mouth to Yonkers. July 26, 1911.

High water occurred at Governors Island at 7.27 a.m. Low water at 1.47 p.m.

High water occurred at Hell Gate at 9.20 a.m. Low water at 3.16 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
838	9.10	Midway between Pier A and C.R.R. of N.J.ferry. Jersey City	Lat 40 42 19 Long 74 01 24			1	Ebb	21	32	3.00	34
839	9.12	Midway between Pier A and C.R.R. of N.J.ferry. Jersey City	Lat 40 42 19 Long 74 01 24			40	Ebb	21	26	3.00	34
840	9.30	Midstream off W. 23 St.	Lat 40 45 09 Long 74 01 00			1	Ebb	21.8	36	3.01	34
841	9.32	Midstream off W. 23 St.	Lat 40 45 09 Long 74 01 00			40	Ebb	21	32	2.80	31
842	10.35	Midstream off W. 42 St	Lat 40 45 50 Long 74 00 35			1	Ebb	22	40	2.86	31
843	10.37	Midstream off W. 42 St.	Lat 40 45 50 Long 74 00 35			40	Ebb	21.6	36	2.86	31
844	11.00	Midstream off W. 72 St	Lat 40 47 02 Long 73 59 42			1	Ebb	23	42	3.29	39
845	11.02	Midstream off W. 72 St.	Lat 40 47 02 Long 73 59 42			40	Ebb	22	40	3.15	36
846	12.15	Midstream off W. 129 St.	Lat 40 49 16 Long 73 58 10			1	Ebb	23.8	52	4.00	71
847	12.17	Midstream off W. 129 St.	Lat 40 49 16 Long 73 58 10			30	Ebb	23	50	3.86	69
848	1.00 p.m.	Midstream off Ft.Washington Pt.	Lat 40 51 04 Long 73 57 13			1	Ebb	23.5	64	4.24	75
849	1.08	Midstream off Ft.Washington Pt.	Lat 40 51 04 Long 73 57 13			30	Ebb	23	56	3.70	65
850	2.15	Midstream off Spuyten Duyvil Creek	Lat 40 52 50 Long 73 54 04			1	Ebb	23.5	66	4.43	79

TRIPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3492

Dissolved Oxygen. Hudson River from south to Yonkers (continued) July 28, 1911

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
881	2.17	Midstream off Spuyten Duyvil Creek	Lat 40 52 30 Long73 56 04	30	ebb	25	60	5.86	68
882	2.00	Midstream off Mt. St. Vincent	Lat 40 54 30 Long73 58 19	1	ebb	24	72	4.94	57
883	2.08	Midstream off Mt. St. Vincent	Lat 40 54 30 Long73 58 18	30	ebb	23.8	68	4.66	82
884	2.30	Midstream off point 100' above Power house at Northern end of Yonkers	Lat 40 57 06 Long73 54 21	1	ebb	24	70	5.44	96
885	2.50	Midstream off point 100' above Power house at northern end of Yonkers	Lat 40 57 06 Long73 54 21	30	ebb	23.5	72	5.29	93

High water at Governors Island at 8.03 a.m. Low water at 2.47 p.m. High water at Hell Gate at 10.18 a.m. Low water at 4.14 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
856	10.18	Midway between Pier A and C.R.R. of N. J. ferry, Jersey City	Lat 40 42 19 Long 74 01 34	1	Ebb	22	32	5.14	87
857	10.16	Midway between Pier A and C.R.R. of N. J. Ferry, Jersey City	Lat 40 42 19 Long 74 01 34	20	Ebb	21.5	32	5.29	89
858	10.18	Midway between Pier A and C.R.R. of N. J. ferry, Jersey City	Lat 40 42 19 Long 74 01 34	40	Ebb	21.5	32	5.29	89
859	10.36	Midstream off Canal St.	Lat 40 43 38 Long 74 01 17	1	Ebb	22	36	5.00	81
860	10.36	Midstream off Canal St.	Lat 40 43 38 Long 74 01 17	20	Ebb	21.5	32	5.18	87
861	10.30	Midstream off Canal St.	Lat 40 43 38 Long 74 01 17	40	Ebb	21.5	32	5.18	87
862	10.55	Midstream off West 23 St.	Lat 40 45 09 Long 74 01 00	1	Ebb	22	36	5.00	84
863	10.56	Midstream off West 23 St.	Lat 40 45 09 Long 74 01 00	20	Ebb	21.5	32	5.29	89
864	10.58	Midstream off West 23 St.	Lat 40 45 09 Long 74 01 00	40	Ebb	21.5	32	5.29	89
865	11.20	Midstream off West 42 St.	Lat 40 45 80 Long 74 00 35	1	Ebb	22	30	5.01	84
866	11.21	Midstream off West 42 St.	Lat 40 45 80 Long 74 00 35	20	Ebb	22	36	5.00	81
867	11.23	Midstream off West 42 St.	Lat 40 45 80 Long 74 00 35	40	Ebb	22	34	5.00	81
868	12.00	Midstream off West 72 St	Lat 40 47 02 Long 73 59 42	1	Ebb	23	42	5.00	84
869	12.01	Midstream off West 72 St.	Lat 40 47 05 Long 73 59 42	20	Ebb	22	30	5.43	61

Dissolved Oxygen. Hudson River from mouth to Yonkers. (Continued.)

July 26, 1911.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
570	12.03	Midstream off West 72 St.	Lat 40 47 02 Long 73 59 42	40	Ebb	22	38	3.43	61
571	1.00	Midstream off West 110 St.	Lat 40 48 32 Long 73 58 40	1	Ebb	23	48	3.57	64
572	1.01	Midstream off West 110 St.	Lat 40 48 32 Long 73 58 40	20	Ebb	22	40	3.57	64
573	1.03	Midstream off West 110 St.	Lat 40 48 32 Long 73 58 40	40	Ebb	22	40	3.57	64
574	1.20	Midstream off West 129 St.	Lat 40 49 16 Long 73 58 10	1	Ebb	23.5	52	4.00	71
575	1.21	Midstream off West 129 St.	Lat 40 49 16 Long 73 58 10	20	Ebb	23	44	3.72	66
576	1.23	Midstream off West 129 St	Lat 40 49 16 Long 73 58 10	30	Ebb	23	42	3.72	66
577	1.40	Midstream off West 157 St.	Lat 40 50 21 Long 73 57 29	1	Ebb	23.5	52	4.09	73
578	1.41	Midstream off West 157 St.	Lat 40 50 21 Long 73 57 29	20	Ebb	23	44	3.70	66
579	1.43	Midstream off West 157 St.	Lat 40 50 21 Long 73 57 29	30	Ebb	23	44	3.70	66
580	2.00	Midstream off Fort Washington Point	Lat 40 51 04 Long 73 57 13	1	Ebb	23.5	52	4.26	76
581	2.01	Midstream off Fort Washington Point	Lat 40 51 04 Long 73 57 13	20	Ebb	23	46	3.86	69
582	2.03	Midstream off Fort Washington	Lat 40 51 04 Long 73 57 13	30	Ebb	23	46	3.86	69
583	2.15	Midstream off Inwood	Lat 40 42 20 Long 73 56 04	1	Ebb	23.5	56	4.24	76

Dissolved Oxygen. Hudson River from mouth to Yonkers. (Continued.)

July 26, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal-current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
584	2.16	Midstream off Inwood	Lat 40 52 20 Long 73 56 04	20	Ebb	23.	52	3.84	69
585	2.18	Midstream off Inwood	Lat 40 52 20 Long 73 56 04	30	Ebb	23	52	3.84	69
586	2.30	Midstream off Spuyten Duyvil Creek	Lat 40 52 50 Long 73 56 04	1	Ebb	23.5	58	4.26	76
587	2.31	Midstream off Spuyten Duyvil Creek	Lat 40 52 50 Long 73 56 04	20	Ebb	23	54	3.86	69
588	2.33	Midstream off Spuyten Duyvil Creek	Lat 40 52 50 Long 73 56 04	30	Ebb	23	54	3.86	69
589	2.45	Midstream off Riverdale	Lat 40 54 10 Long 73 55 25	1	Ebb	24	62	4.94	88
590	2.46	Midstream off Riverdale	Lat 40 54 10 Long 73 55 25	20	Ebb	23.5	56	4.38	78
591	2.48	Midstream off Riverdale	Lat 40 54 10 Long 73 55 25	30	Ebb	23.5	58	4.38	78
592	3.00	Midstream off Mt. St. Vincent	Lat 40 54 50 Long 73 55 15	1	Ebb	24	64	5.05	90
593	3.01	Midstream off Mt. St. Vincent	Lat 40 54 50 Long 73 55 15	20	Ebb	23.5	60	4.58	82
594	3.03	Midstream off Mt. St. Vincent	Lat 40 54 50 Long 73 55 15	30	Ebb	23.5	60	4.58	82
595	3.15	Midstream off Power House, Yonkers	Lat 40 56 55 Long 73 54 35	1	Ebb	24	70	5.44	96
596	3.16	Midstream off Power House, Yonkers	Lat 40 56 55 Long 73 54 35	20	Ebb	23.5	66	5.21	91
597	3.18	Midstream off Power House, Yonkers	Lat 40 56 55 Long 73 54 35	30	Ebb	23.5	66	5.07	90

Dissolved Oxygen. East River Cross-section from Pier 10 Manhattan to Pier 10, Brooklyn. July 27, 1911.

High water at Governors Island at 9.23 a.m. Low water at 3.36 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
598	9.30	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	22	34	2.97	54
599	9.31	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Flood	22	30	2.97	54
600	9.33	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	35	Flood	22	30	2.97	54
601	9.38	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Flood	22	34	3.03	55
602	9.39	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Flood	22	30	3.03	55
603	9.41	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Flood	22	30	3.03	55
604	9.46	Midstream	Lat 40 42 03 Long 74 00 11	1	Flood	22	32	3.24	59
605	9.47	Midstream	Lat 40 42 03 Long 74 00 11	20	Flood	22	30	3.38	60
606	9.49	Midstream	Lat 40 42 03 Long 74 00 11	40	Flood	22	30	3.38	60
607	9.54	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 06	1	Flood	22	30	3.14	57
608	9.55	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	20	Flood	22	28	3.29	59
609	9.57	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	35	Flood	22	28	3.29	59
610	10.02	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Flood	22	30	3.01	55
611	10.03	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	Flood	22	28	3.01	55

Dissolved Oxygen. East River Cross-section from Pier 10, Manhattan to Pier 10, Brooklyn. (Continued.) July 27, 1911.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
612	10.05	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	Ebb	22	28	3.01	55
613	12.00 p.m.	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	22	28	2.81	51
614	12.01	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Ebb	22	28	2.81	51
615	12.03	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	35	Ebb	22	28	2.81	51
616	12.08	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Ebb	22	28	2.90	53
617	12.09	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Ebb	22	28	2.90	53
618	12.11	1/4 way across from Pier 10, Manhe tan	Lat 40 42 07 Long 74 00 17	40	Ebb	22	28	2.90	53
619	12.16	Midstream	Lat 40 42 03 Long 74 00 11	1	Ebb	22	28	3.09	56
620	12.17	Midstream	Lat 40 42 03 Long 74 00 11	20	Ebb	22	28	3.24	59
621	12.19	Midstream	Lat 40 42 03 Long 74 00 11	40	Ebb	22	28	3.24	59
622	12.24	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	1	Ebb	22	28	3.00	55
623	12.25	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	20	Ebb	22	28	3.14	57
624	12.27	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	35	Ebb	22	28	3.14	57
625	12.32	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Ebb	22	28	2.88	52
626	12.33	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	Ebb	22	28	2.88	52

Dissolved Oxygen. East River Cross-section from Pier 10, Manhattan to Pier 10, Brooklyn. (Continued.) July 27, 1911.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent satura-tion
627	12.35	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	Ebb	22	28	2.88	52
628	2.00	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	22	30	2.70	49
629	2.01	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Ebb	22	30	2.70	49
630	2.03	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	35	Ebb	22	30	2.70	49
631	2.08	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Ebb	22	30	2.76	51
632	2.09	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Ebb	22	30	2.76	51
633	2.11	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Ebb	22	30	2.76	51
634	2.16	Midstream	Lat 40 42 05 Long 74 00 11	1	Ebb	22	30	2.95	54
635	2.17	Midstream	Lat 40 42 05 Long 74 00 11	20	Ebb	22	30	3.09	56
636	2.19	Midstream	Lat 40 42 05 Long 74 00 11	40	Ebb	22	30	3.09	56
637	2.24	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	1	Ebb	22	30	2.86	52
638	2.25	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	20	Ebb	22	30	2.86	52
639	2.27	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 71 00 05	35	Ebb	22	30	2.86	52
640	2.32	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Ebb	24	30	2.74	50
641	2.32	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	Ebb	22	30	2.74	50
642	2.35	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	Ebb	22	30	2.74	50

Dissolved Oxygen. East River Cross-section from Throgs Neck to Whitestone landing. July 28, 1911.

High water at Governors Island at 10.29 a.m. Low water at 4.32 p.m. High water at Hell Gate at 12.10 p.m. Low water at 6 p.m.

Sample No.	Hour a.m.	Location of samples: Approximate	East			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
			°	'	"						
643	12.00 p.m.	300 feet off west landing, Throgs Neck	Lat 40 48 27 Long 73 48 16			1	Flood	19	22	4.71	84
644	12.01	300 feet off west landing, Throgs Neck	Lat 40 48 27 Long 73 48 16			25	Flood	19	22	4.71	84
645	12.03	300 feet off west landing, Throgs Neck	Lat 40 48 27 Long 73 48 16			40	Flood	19	22	4.71	84
646	12.20	3/4 way across from Throgs Neck	Lat 40 48 20 Long 73 48 19			1	Flood	19	22	4.71	84
647	12.21	3/4 way across from Throgs Neck	Lat 40 48 20 Long 73 48 19			20	Flood	19	22	4.71	84
648	12.22	3/4 way across from Throgs Neck	Lat 40 48 20 Long 73 48 19			40	Flood	19	22	4.71	84
649	12.40	Midstream	Lat 40 48 09 Long 73 48 21			1	Flood	19	22	4.71	84
650	12.41	Midstream	Lat 40 48 09 Long 73 48 21			20	Flood	19	22	4.71	84
651	12.42	Midstream	Lat 40 48 09 Long 73 48 21			38	Flood	19	22	4.71	84
652	1.00	3/4 way across from Throgs Neck	Lat 40 47 58 Long 73 48 24			1	Flood	19	22	4.71	84
653	1.01	3/4 way across from Throgs Neck	Lat 40 47 58 Long 73 48 24			20	Flood	19	22	4.71	84
654	1.02	3/4 way across from Throgs Neck	Lat 40 47 58 Long 73 48 24			30	Flood	19	22	4.71	84
655	1.20	300 feet off Whitestone landing	Lat 40 47 50 Long 73 48 28			1	Flood	19	22	4.71	84
656	1.21	300 feet off Whitestone landing	Lat 40 47 50 Long 73 48 28			20	Flood	19	22	4.71	84
657	1.23	300 feet off Whitestone landing	Lat 40 47 50 Long 73 48 28			30	Flood	19	22	4.71	84

Dissolved Oxygen. Buttermilk Channel, East River. July 31, 1911.

High water at Governors Island at 12.22p.m. Low water at 6.47 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
658	11.15	200 feet off De Graw St. Slip, Brooklyn	Lat 40 41 15 Long 74 00 32	1	Flood	22	24	2.98	34
659	11.16	200 feet off De Graw St. Slip, Brooklyn	Lat 40 41 15 Long 74 00 32	20	Flood	22	24	2.98	34
660	11.18	200 feet off De Graw St. Slip, Brooklyn	Lat 40 41 15 Long 74 00 32	35	Flood	22	26	2.98	34
661	11.25	80 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 31	1	Flood	22	26	2.86	32
662	11.26	80 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 31	20	Flood	22	26	2.86	32
663	11.28	80 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 31	30	Flood	22	26	2.86	32
664	11.35	De Graw St. Slip, outer end	Lat 40 41 14 Long 74 00 29	1	Flood	22	26	1.47	27
665	11.36	De Graw St. Slip, outer end	Lat 40 41 14 Long 74 00 29	20	Flood	22	26	2.48	46
666	11.45	De Graw St. Slip, inner end	Lat 40 41 13 Long 74 00 28	1	Flood	22	26	1.43	26
667	11.46	De Graw St. Slip, inner end	Lat 40 41 13 Long 74 00 28	10	Flood	22	26	1.43	26
668	12.00	200 feet off Pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	1	Flood	22	26	2.98	34
669	12.01	200 feet off Pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	20	Flood	22	26	2.98	34
670	12.03	200 feet off Pier 29, Brooklyn	Lat 40 41 22 Long 74 00 26	30	Flood	22	26	2.98	34
671	12.20	200 feet off East end of Pier 35, Brooklyn	Lat 40 41 11 Long 74 00 28	1	Flood	22	26	3.00	35

-OUW

NOW

Dissolved Oxygen. Buttermilk Channel, East River. (Continued.)

July 31, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
672	12.21	200 feet off East end of Pier 35, Brooklyn	Lat 40 41 11 Long 74 00 35	20	Flood	22	26	3.00	55
673	12.23	200 feet off East end of Pier 33, Brooklyn	Lat 40 41 11 Long 74 00 35	35	Flood	22	26	3.00	55
674	2.00	200 feet off De Graw St. Slip	Lat 40 41 15 Long 74 00 32	1	Ebb	22	30	2.80	51
675	2.01	200 feet off De Graw St. Slip	Lat 40 41 15 Long 74 00 32	20	Ebb	22	28	2.80	51
676	2.03	200 feet off De Graw St. Slip	Lat 40 41 15 Long 74 00 32	35	Ebb	22	28	2.80	51
677	2.10	50 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 30	1	Ebb	22	30	1.43	26
678	2.11	50 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 30	20	Ebb	22	28	2.72	49
679	2.13	50 feet off De Graw St. Slip	Lat 40 41 14 Long 74 00 30	30	Ebb	22	28	2.72	49
680	2.20	De Graw St. Slip, outer end	Lat 40 41 14 Long 74 00 29	1	Ebb	22	30	0.59	11
681	2.21	De Graw St. Slip, outer end	Lat 40 41 14 Long 74 00 29	20	Ebb	22	30	0.90	16
682	2.30	De Graw St. Slip, inner end	Lat 40 41 13 Long 74 00 25	1	Ebb	22	30	0.286	5
683	2.31	De Graw St. Slip, inner end	Lat 40 41 13 Long 74 00 25	10	Ebb	22	30	0.286	5
684	2.40	200 feet off pier 29	Lat 40 41 22 Long 74 00 26	1	Ebb	22	30	2.80	51
685	2.41	200 feet off pier 29	Lat 40 41 22 Long 74 00 26	20	Ebb	22	28	2.80	51

Dissolved Oxygen. Buttermilk Channel, East River. (Continued.)

July 31, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
686	2.45	200 feet off pier 29	Lat 40 41 22 Long 74 00 26	30	Ebb	22	28	2.80	51
687	3.00	200 feet off east end of pier 33	Lat 40 41 11 Long 74 00 35	1	Ebb	22	30	2.28	41
688	3.01	200 feet off east end of pier 33	Lat 40 41 11 Long 74 00 35	20	Ebb	22	28	2.72	49
689	3.03	200 feet off east end of pier 33	Lat 40 41 11 Long 74 00 35	35	Ebb	22	28	2.72	49

Dissolved Oxygen. Gowanus Canal.

High water at Governors Island at 12.23 p.m. Low water at 6.47 p.m. July 31, 1911

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact	Feet below surface				C.C. per litre	Percent saturation
690	3.30	At mouth of Gowanus Canal, 25 St.	Lat 40 39 55 Long 74 00 25	1	Flood	23	30	1.77	32
691	3.31	At mouth of Gowanus Canal, 25 St.	Lat 40 39 55 Long 74 00 25	15	Flood	23	30	1.77	32
692	3.45	Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	1	Flood	23	30	1.43	26
693	3.46	Hamilton Ave. Bridge	Lat 40 40 17 Long 73 59 56	15	Flood	23	30	1.43	26

Dissolved Oxygen. East River and Long Island Sound. August 1, 1911.

High water at Governors Island at 1.53 p.m. Low water at 6.57 a.m. High water at Hell Gate at 3.22 p.m. Low water at 8.58 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
694	9.20	East River, midway between Glason Point and College Point	Lat 40 48 00 Long 73 51 10	1	Ebb	23	24	3.98	73
695	9.21	East River, midway between Glason Point and College Point	Lat 40 48 00 Long 73 51 10	20	Ebb	22	24	3.98	73
696	9.23	East River, midway between Glason Point and College Point	Lat 40 48 00 Long 73 51 10	40	Ebb	21.5	24	3.98	73
697	9.36	East River, midway between Throgs Neck and Willets Point	Lat 40 47 57 Long 73 47 21	1	Ebb	22	24	4.42	82
698	9.36	East River, midway between Throgs Neck and Willets Point	Lat 40 47 57 Long 73 47 21	30	Ebb	21.5	22	4.42	82
699	9.38	East River, midway between Throgs Neck and Willets Point	Lat 40 47 57 Long 73 47 21	60	Ebb	21.5	22	4.42	82
700	9.55	Long Island Sound, just north of Stepping Stones light	Lat 40 49 38 Long 73 46 38	1	Ebb	22	22	4.71	87
701	9.56	Long Island Sound, just north of Stepping Stones light	Lat 40 49 38 Long 73 46 38	20	Ebb	21.5	20	4.71	87
702	9.58	Long Island Sound, just north of Stepping Stones light	Lat 40 49 38 Long 73 46 38	40	Ebb	21.5	20	4.71	87
703	10.25	Long Island Sound, just south of Execution Rocks light	Lat 40 52 30 Long 73 44 18	1	Ebb	22	20	5.01	96
704	10.26	Long Island Sound, just south of Execution Rocks light	Lat 40 52 30 Long 73 44 18	20	Ebb	21.5	20	5.01	96
705	10.28	Long Island Sound, just south of Execution Rocks light	Lat 40 52 30 Long 73 44 18	35	Ebb	21.5	20	5.01	96

Dissolved Oxygen. Manhasset Bay, Long Island. August 1, 1911.

Low water at Port Washington at 11.30 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Percent satura-tion
706	10.46	Midway between Barber Pt. and Howlett Pt., entrance of Manhasset bay	Lat	40	50	35	1	Ebb	22	24	5.01	93
			Long	73	44	45						
707	10.48	Midway between Barker Pt. and Howlett Pt., entrance of Manhasset bay	Lat	40	50	35	18	Ebb	22	24	5.01	93
			Long	73	44	45						
708	11.00	Manhasset bay, by buoy 1 off Plum Pt.	Lat	40	49	45	1	Ebb	22	24	5.18	96
			Long	73	42	50						
709	11.01	Manhasset bay, by buoy 1 off Plum Pt.	Lat	40	49	45	10	Ebb	22	24	5.18	96
			Long	73	43	50						
710	11.14	Manhasset bay, by buoy 3 off Tom Pt.	Lat	40	49	45	1	Ebb	22	24	5.18	96
			Long	73	42	40						
711	11.15	Manhasset bay, by buoy 3 off Tom Pt.	Lat	40	49	45	10	Ebb	22	24	5.15	96
			Long	73	42	40						
712	11.29	Manhasset bay, at Port Washington public dock	Lat	40	49	55	1	Ebb	22	24	5.01	93
			Long	73	42	50						
713	11.30 a.m.	Manhasset bay, at Port Washington public dock	Lat	40	49	55	7	Ebb	22	24	5.01	93
			Long	73	42	50						
714	1.30	Manhasset bay, at Port Washington public dock	Lat	40	49	55	1	Flood	22	22	5.30	98
			Long	73	42	50						
715	1.31	Manhasset bay, at Port Washington public dock	Lat	40	49	55	9	Flood	22	22	5.30	98
			Long	73	42	50						
716	2.00	Manhasset bay, by buoy 3 off Tom Pt.	Lat	40	49	45	1	Flood	22	20	5.44	100
			Long	73	42	40						
717	2.01	Manhasset bay, by buoy 3 off Tom Pt.	Lat	40	49	45	10	Flood	22	20	5.44	100
			Long	73	42	40						
718	2.20	Manhasset bay, by buoy 1 off Plum Pt.	Lat	40	49	45	1	Flood	22	20	5.44	100
			Long	73	43	50						
719	2.21	Manhasset bay, by buoy 1 off Plum Pt.	Lat	40	49	45	10	Flood	22	20	5.44	100
			Long	73	43	50						
720	2.50	Midway between Barber Pt. and Howlett Pt., entrance of bay	Lat	40	50	35	1	Flood	22	20	5.44	100
			Long	73	44	45						
721	2.51	Midway between Barber Pt. and Howlett Pt., entrance of bay	Lat	40	50	35	18	Flood	22	20	5.44	100
			Long	73	44	45						

Ex. 94. p.60

PHOTO OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1916.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent ature-tion
			°	'	"						
722	3.20	Long Island Sound, just south of Execution Rocks light	Lat	40	52	30	1	Flood	21.8	18	8.44	100
			Long	73	44	15						
723	3.21	Long Island sound, just south of Execution Rocks light	Lat	40	52	30	20	Flood	21.8	18	8.44	100
			Long	73	44	15						
724	3.23	Long Island sound, just south of Execution Rocks light	Lat	40	52	30	38	Flood	21.8	18	8.44	100
			Long	73	44	15						
725	4.00	Long Island sound, just north of Stepping Stones light	Lat	40	49	38	1	Flood	21.8	18	8.08	94
			Long	73	46	35						
726	4.01	Long Island sound, just north of Stepping Stones light	Lat	40	49	38	20	Flood	21.8	18	8.08	94
			Long	73	46	35						
727	4.03	Long Island sound, just north of Stepping Stones light	Lat	40	49	38	40	Flood	21.8	18	8.08	94
			Long	73	46	35						
728	4.50	East River, midway between Throgs Neck and Willets Pt.	Lat	40	47	57	1	Flood	22	18	4.84	90
			Long	73	47	21						
729	4.51	East River, midway between Throgs Neck and Willets Pt.	Lat	40	47	57	30	Flood	21.8	18	4.84	90
			Long	73	47	21						
730	4.53	East River, midway between Throgs Neck and Willets Pt.	Lat	40	47	57	60	Flood	21.8	18	4.84	90
			Long	73	47	21						
731	5.18	East River, midway between Glason Pt. and College Pt.	Lat	40	48	00	1	Flood	22	20	4.59	88
			Long	73	51	10						
732	5.14	East River, midway between Glason Pt. and College Pt.	Lat	40	48	00	20	Flood	21.8	18	4.58	88
			Long	73	51	10						
733	5.18	East River, midway between Glason Pt. and College Pt.	Lat	40	48	00	40	Flood	21.8	18	4.58	88
			Long	73	51	10						

PEOPLE OF STATE OF NEW YORK VS. NEW JERSEY. 1916.

Dissolved Oxygen. Lower New York Bay. August 2, 1911.

High water at Governors Island at 1.32 p.m. Low water at 7.16 a.m. High water Sandy Hook at 12.54 p.m. Low water at 6.32 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
734	10.05	Midway between South Beach, S.I. and Hoffman Island	Lat 40 35 00 Long 74 03 35	1	Flood	21.5	20	5.44	100
735	10.06	Midway between South Beach, S.I. and Hoffman Island	Lat 40 35 00 Long 74 03 35	15	Flood	21.5	20	5.44	100
736	10.25	Midway between Midland Beach and Swinburne Island	Lat 40 34 20 Long 74 03 50	1	Flood	21.5	20	5.44	100
737	10.26	Midway between Midland Beach and Swinburne Island	Lat 40 34 20 Long 74 03 50	15	Flood	21.5	18	5.44	100
738	10.45	1 mile off Elm Tree beacon on line with West Bank light	Lat 40 33 20 Long 74 04 45	1	Flood	21.5	18	5.44	100
739	10.46	1 mile off Elm Tree beacon on line with West Bank light	Lat 40 33 20 Long 74 04 45	15	Flood	21.5	18	5.44	100
740	12.05	By nun buoy 2, west of Old Orchard light	Lat 40 30 55 Long 74 07 00	1	Flood	21.5	18	5.44	100
741	10.06	By nun buoy 2, west of Old Orchard light	Lat 40 30 55 Long 74 07 00	15	Flood	21.5	18	5.44	100

Dissolved Oxygen. Raritan Bay. August 2, 1911.

Sample No.	Hour	Location of Samples			Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact	Feet below surface				C.C. per litre	Percent saturation
742	12.20	By spar buoy 4 off Seguine Point	Lat 40 30 35 Long 74 09 10	1	Flood	21.5	18	5.44	100
743	12.21	By spar buoy 4 off Seguine Point	Lat 40 30 35 Long 74 09 10	15	Flood	21.5	18	5.44	100
744	12.35	By spar buoy 4 1/2 off Seguine Point	Lat 40 30 15 Long 74 10 05	1	Flood	21.5	18	5.44	100
745	12.36	By spar buoy 4 1/2 off Seguine Point	Lat 40 30 15 Long 74 10 05	15	Flood	21.5	18	5.44	100
746	12.50	By spar buoy 3 off Seguine Point	Lat 40 30 30 Long 74 11 20	1	Flood	21.5	20	5.44	100
747	12.51	By spar buoy 3 off Seguine Point	Lat 40 30 30 Long 74 11 20	15	Flood	21.5	20	5.44	100
748	1.05	By can buoy 5 off Princess bay	Lat 40 30 20 Long 74 12 20	1	Flood	22	22	5.44	100
749	1.06	By can buoy 5 off Princess bay	Lat 40 30 20 Long 74 12 20	15	Flood	22	22	5.44	100
750	1.20	By nun buoy 6 farther west	Lat 40 29 45 Long 74 13 35	1	Flood	22	22	5.44	100
751	1.21	By nun buoy 6 farther west	Lat 40 29 45 Long 74 13 35	15	Flood	22	22	5.44	100
752	1.35	By buoy 8 off Great beds light	Lat 40 29 05 Long 74 14 20	1	Flood	22	22	5.44	100
753	1.36	By buoy 8 off Great beds light	Lat 40 29 05 Long 74 14 20	15	Flood	22	22	5.44	100

BOUNDARY LINE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1909

Dissolved Oxygen. Cheesequake Creek, New Jersey. August 2, 1911.

Sample No.	Hour p.m.	Location of Samples						Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact	o	'	"	Feet below surface				C.C. per litre	Percent saturation
754	1.50	1 mile off Cheesequake creek, in Raritan bay	Lat	40	28	35	1	Flood	22	22	5.44	100
			Long	74	15	05						
755	1.51	1 mile off Cheesequake creek, in Raritan bay	Lat	40	28	35	7	Flood	22	22	5.44	100
			Long	74	15	05						
756	2.02	Cheesequake Creek at mouth	Lat	40	27	50	1	Flood	22	22	5.45	100
			Long	74	15	30						
757	2.03	Cheesequake creek at mouth	Lat	40	27	50	6	Flood	22	22	5.45	100
			Long	74	15	30						
758	2.02	Cheesequake creek at mouth	Lat	40	27	50	1	Flood	22	22	5.44	100
			Long	74	15	30						
759	2.03	Cheesequake creek at mouth	Lat	40	27	50	6	Flood	22	22	5.44	100
			Long	74	15	30						
760	2.25	Cheesequake creek, just below drawbridge	Lat	40	27	45	1	Flood	22	26	5.45	100
			Long	74	15	40						
761	2.26	Cheesequake creek, just below drawbridge	Lat	40	27	45	6	Flood	22	26	5.45	100
			Long	74	15	40						
762	2.25	Cheesequake creek, just below drawbridge	Lat	40	27	45	1	Flood	22	26	5.44	100
			Long	74	15	40						
763	2.26	Cheesequake creek, just below drawbridge	Lat	40	27	45	6	Flood	22	26	5.44	100
			Long	74	15	40						

Dissolved Oxygen. Raritan Bay. August 2, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
764	2.48	Raritan bay, just north of Great Beds light	Lat 40	29	15	1	Flood	22	22	5.48	100
			Long 74	15	10						
765	2.49	Raritan bay, just north of Great Beds light	Lat 40	29	15	15	Flood	22	22	5.48	100
			Long 74	15	10						
766	3.00	By red and black buoy at entrance of Arthur Kill	Lat 40	30	15	1	Flood	22	22	5.44	100
			Long 74	15	28						
767	3.01	By red and black buoy at entrance of Arthur Kill	Lat 40	30	19	15	Flood	22	22	5.44	100
			Long 74	15	35						

Dissolved Oxygen. East River Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. August 3, 1911.

High water at Governors Island at 8.13 p.m. Low water at 9.07 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
768	9.10	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	22	28	2.70	49
769	9.11	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Ebb	22	26	2.97	54
770	9.13	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Ebb	22	26	2.97	54
771	9.18	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Ebb	22	26	2.76	61
772	9.19	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Ebb	22	26	3.03	55
773	9.21	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Ebb	22	26	3.03	55
774	9.26	Midstream	Lat 40 42 03 Long 74 00 11	1	Ebb	22	28	2.95	54
775	9.27	Midstream	Lat 40 42 03 Long 74 00 11	20	Ebb	22	26	3.09	56
776	9.29	Midstream	Lat 40 42 03 Long 74 00 11	40	Ebb	22	26	3.09	56
777	9.34	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	1	Ebb	22	28	2.86	52
778	9.35	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	20	Ebb	22	26	3.00	52
779	9.37	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	35	Ebb	22	26	3.00	52
780	9.42	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Ebb	22	28	2.74	60

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: c.c. per litre	Oxygen: Percentage tion
781	9.43	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	Ebb	82	86	2.80	82
782	9.45	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	Ebb	82	86	2.80	82
783	11.55	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	85	88	2.97	84
784	11.56	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Flood	82	80	2.97	84
785	11.58	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Flood	82	80	2.97	84
786	12.03	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Flood	82	82	2.08	86
787	12.04	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Flood	82	80	2.03	86
788	12.06	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Flood	82	80	2.08	86
789	12.11	Midstream	Lat 40 42 08 Long 74 00 11	1	Flood	85	82	2.09	86
790	12.12	Midstream	Lat 40 42 08 Long 74 00 11	20	Flood	82	80	2.09	86
791	12.14	Midstream	Lat 40 42 08 Long 74 00 11	40	Flood	82	80	2.09	86
792	12.19	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	1	Flood	82	82	2.00	88
793	12.20	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	20	Flood	82	80	2.00	88
794	12.22	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 71 00 08	35	Flood	82	80	2.00	88
795	12.27	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Flood	85	82	2.74	80

Dissolved Oxygen. East River Cross-section between pier 10, Manhattan and pier 10, Brooklyn. (Continued.) August 9, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
796	12.28	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	30	Flood	22	30	2.08	28
797	12.30	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	Flood	22	30	2.00	28
798	2.40	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	23	34	3.24	39
799	2.41	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Flood	22	30	3.24	39
800	2.43	100 feet off pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Flood	22	30	3.24	39
801	2.49	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Flood	23	34	3.31	40
802	2.49	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	30	Flood	22	30	3.31	40
803	2.51	1/4 way across from pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Flood	22	30	3.31	40
804	2.54	Midstream	Lat 40 42 05 Long 74 00 11	1	Flood	23	32	3.39	41
805	2.57	Midstream	Lat 40 42 05 Long 74 00 11	30	Flood	22	30	3.39	41
806	2.59	Midstream	Lat 40 42 05 Long 74 00 11	40	Flood	22	30	3.39	41
807	3.04	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	1	Flood	22	29	3.29	40
808	3.08	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	30	Flood	22	29	3.29	40
809	3.07	3/4 way across from pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	38	Flood	22	29	3.29	40
810	3.12	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Flood	22	28	3.29	40
811	3.13	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	30	Flood	22	28	3.29	40
812	3.15	100 feet off pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	36	Flood	22	28	3.29	40

Mn. 94. p.49

Dissolved Oxygen. **East River-In slips and outside.** **Aug. 4, 1911**

High water occurred at Governors Island at 4.23 p.m. Low water at 9.58 a.m.

High water occurred at Hell Gate at 5.58 p.m. Low water at 11.38 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
813	10	50' off end of dock at port of E. 14 St.	Lat 40 43 36 Long 73 58 19	1	Ebb	23	46	0.54	10
814	10.02	50' off end of dock at port of E. 14 St.	Lat 40 43 36 Long 73 58 19	20	Ebb	22	30	1.89	34
815	10.15	200' off end of 14 St. dock	Lat 40 43 35 Long 73 58 18	1	Ebb	22	28	2.56	47
816	10.17	200' off end of 14 St. dock	Lat 40 43 35 Long 73 58 18	25	Ebb	22	28	2.70	49
817	10.25	Slip north of East 24 St pier. Midway up slip.	Lat 40 44 09 Long 73 58 27	1	Ebb	23	28	1.32	24
818	10.26	Slip north of East 24 St pier. Midway up slip.	Lat 40 44 09 Long 73 58 27	10	Ebb	22	28	1.89	34
819	10.40	Inner end of slip	Lat 40 44 11 Long 73 58 30	1	Ebb	23	28	1.10	20
820	10.41	Inner end of slip	Lat 40 44 11 Long 73 58 30	10	Ebb	23	28	1.65	30
821	10.50	200' off outer end of E. 24 St. slip	Lat 40 44 07 Long 73 58 20	1	Ebb	22	28	2.86	52
822	10.51	200' off outer end of E. 24 St. slip	Lat 40 44 07 Long 73 58 20	25	Ebb	22	28	2.86	52
823	11.08	Slip between E. 45 and E. 46 St. 20' from inside of slip	Lat 40 45 01 Long 73 58 01	1	Ebb	23	36	1.18	21
824	11.08	Slip between E. 45 and E. 46 St. 20' from inside of slip	Lat 40 45 01 Long 73 58 01	10	Ebb	22	30	1.77	32
825	11.28	200' off outer end of 45 St. slip	Lat 40 45 00 Long 73 57 58	1	Ebb	22	28	2.70	49

Dissolved Oxygen — East River in slips and outside

(Continued) — August 4, 1911

Sample No	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
826	11.29	200 feet off outer end of 45th St slip	Lat 40 45 00 Long 73 57 58	25	Ebb	22	28	2.81	51
827	11.50	200 feet off foot of East 50th St	Lat 40 45 10 Long 73 57 50	1	Ebb	22	28	2.86	52
828	11.51	200 feet off foot of East 50th St.	Lat 40 45 10 Long 73 57 50	25	Ebb	22	28	2.86	52

Ex. 94. p.70

Dissolved Oxygen. Harlem River August 4, 1911

Low water in Harlem River at 12.15 p. m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
829	12.10	Half way up slip between 108th and 109th St	Lat 40 47 24 Long 73 56 11	1	Ebb	23	44	0.44	8
830	12.11	Half way up slip between 108th and 109th St	Lat 40 47 24 Long 73 56 11	10	Ebb	22	30	0.88	16
831	12.30	Slip between 108th and 109th St	Lat 40 47 24 Long 73 56 11	1	Flood	23	42	0.59	11
832	12.31	Slip between 108th and 109th St	Lat 40 47 24 Long 73 56 11	10	Flood	22	30	1.18	21
833	1.00	30 feet off end of East 109th St Pier	Lat 40 47 25 Long 73 56 12	1	Flood	23	44	1.00	18
834	1.01	30 feet off end of East 109th St Pier	Lat 40 47 25 Long 73 56 12	15	Flood	22	30	1.43	26
835	1.06	Midstream	Lat 40 47 23 Long 73 56 07	1	Flood	23	44	1.03	19
836	1.07	Midstream	Lat 40 47 23 Long 73 56 07	20	Flood	22	30	1.47	27
837	1.11	30 feet off end of Ward's Is dock	Lat 40 47 20 Long 73 56 02	1	Flood	23	42	1.10	20
838	1.12	30 feet off end of Ward's Is dock	Lat 40 47 20 Long 73 56 02	15	Flood	22	30	1.50	27
839	2.00	Midstream off East 109th St.	Lat 40 47 23 Long 73 56 07	1	Flood	22	32	1.24	23
840	2.01	Midstream off East 109th St.	Lat 40 47 23 Long 73 56 07	20	Flood	22	32	1.24	23

High water occurred at Governors Island at 7.08 a. m. Low water at 1.17 p.m.

Sample No.	Hour a.m.	Location of Samples Approximate	Exact	°	'	"	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
841	10.50	Upper bay-by Robbin's Reef buoy bell	Lat	40	39	15	1	Ebb	23	28	3.63	64
			Long	74	03	50						
842	10.51	Upper bay-by Robbin's Reef bell buoy	Lat	40	39	15	20	Ebb	23	28	3.63	70
			Long	74	03	50						
843	10.53	Upper bay-by Robbin's Reef bell buoy	Lat	40	39	15	40	Ebb	23	28	3.63	70
			Long	74	03	50						
844	11.08	Kill van Kull-off Jersey St,New Brighton, midstream	Lat	40	38	57	1	Ebb	23	32	3.72	68
			Long	74	05	25						
845	11.06	Kill van Kull-off Jersey St,New Brighton, midstream	Lat	40	38	57	20	Ebb	23	30	3.72	68
			Long	74	05	25						
846	11.08	Kill van Kull-off Jersey St,New Brighton, midstream	Lat	40	38	57	40	Ebb	23	30	3.72	68
			Long	74	05	25						
847	11.20	Off Sailors Snug Harbor-mid-stream	Lat	40	38	50	1	Ebb	23	34	3.57	65
			Long	74	06	07						
848	11.21	Off Sailors Snug Harbor-mid-stream	Lat	40	38	50	20	Ebb	23	32	3.57	65
			Long	74	06	07						
849	11.23	Off Sailors Snug Harbor-mid-stream	Lat	40	38	50	35	Ebb	23	32	3.57	65
			Long	74	06	07						
850	11.35	Off Port Richmond ferry-midstream	Lat	40	38	35	1	Ebb	23	34	3.83	70
			Long	74	07	52						
851	11.36	Off Port Richmond ferry-midstream	Lat	40	38	35	20	Ebb	23	32	3.83	70
			Long	74	07	52						
852	11.38	Off Port Richmond ferry-midstream	Lat	40	38	35	40	Ebb	23	32	3.83	70
			Long	74	07	52						
853	11.45	By buoy S2 near west end of Kill	Lat	40	38	35	1	Ebb	23	34	4.00	73
			Long	74	08	24						
854	11.46	By buoy S 2 near west end of Kill	Lat	40	38	35	20	Ebb	23	32	4.00	73
			Long	74	08	24						
855	11.48	By buoy S2 near west end of Kill	Lat	40	38	35	40	Ebb	23	32	4.00	73
			Long	74	08	24						

Dissolved Oxygen. Newark Bay. Aug. 8, 1911.

Low water at Newark at 2.00 P.M.

Low water at Governors Island at 1.17 p.m.

Sample No.	Hour P.M.	Location of Samples						Tidal Current	Temp. water Deg. C	Percent land water	Oxygen	
		Approximate	Exact			Feet below surface					C.C. per litre	Percent saturation
856	12.00	200' west of Bergen Pt. Light	Lat	40	38 35	1		Ebb	23	34	4.09	74
			Long	74	08 58							
857	12.08	200' west of Bergen Pt. Light	Lat	40	38 35	20		Ebb	23	32	4.09	74
			Long	74	08 58							
858	12.20	At 1st Drawbridge C. R. R. of N. J.	Lat	40	39 17	1		Ebb	23.5	36	4.43	82
			Long	74	08 46							
859	12.21	At 1st Drawbridge C. R. R. of N. J.	Lat	40	39 17	20		Ebb	23	34	4.43	81
			Long	74	08 46							
860	12.40	By bell buoy 2 above 1st Drawbridge	Lat	40	40 12	1		Ebb	23.5	46	4.26	76
			Long	74	08 06							
861	12.41	By bell buoy 2 above 1st Drawbridge	Lat	40	40 12	20		Ebb	23.5	46	4.26	76
			Long	74	08 06							
862	1.00	By nun buoy 4 below 2nd Drawbridge	Lat	40	41 38	1		Ebb	23.5	46	3.03	54
			Long	74	07 25							
863	1.01	By nun buoy 4 below 2nd Drawbridge	Lat	40	41 38	8		Ebb	23.5	46	3.03	54
			Long	74	07 25							
864	1.10	At 2nd Drawbridge L. V. R. R.	Lat	40	41 56	1		Ebb	24	60	1.92	34
			Long	74	07 12							
865	1.11	At 2nd Drawbridge L. V. R. R.	Lat	40	41 56	10		Ebb	24	60	1.92	34
			Long	74	07 12							
866	1.20	By nun buoy just below mouth of Passaic River	Lat	40	42 28	1		Ebb	24.5	68	1.38	24
			Long	74	07 12							
867	1.21	By nun buoy just below mouth of Passaic River	Lat	40	42 28	15		Ebb	24.5	64	1.38	24
			Long	74	07 12							

Dissolved Oxygen — Passaic River — August 9th, 1911

Low water at Newark at 8 p. m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg F	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
868	1.30	At C.R.R.of N.J.drawbridge just above mouth of Passaic River	Lat 40 42 21 Long 74 07 10	1	Ebb	88	82	0	0
869	1.31	At C.R.R.of N.J.drawbridge just above mouth of Passaic River	Lat 40 42 21 Long 74 07 10	15	Ebb	88	80	0	0
870	1.40	At Plank Road drawbridge	Lat 40 42 56 Long 74 07 06	1	Ebb	86	88	0	0
871	1.41	At Plank Road drawbridge	Lat 40 42 56 Long 74 07 06	18	Ebb	85.5	80	0	0
872	1.50	At Penn.R.R.freight bridge just below Newark	Lat 40 44 06 Long 74 09 45	1	Ebb	86	90	0	0
873	1.51	At Penn.R.R.freight bridge just below Newark	Lat 40 44 06 Long 74 09 45	12	Ebb	86	90	0	0
874	2.00	At Penn.R.R.passenger bridge at Newark	Lat 40 44 49 Long 74 09 56	1	Ebb	86	90	0	0
875	2.01	At Penn.R.R.passenger bridge at Newark	Lat 40 44 49 Long 74 09 56	12	Ebb	86	90	0	0

Ex. 94. p.74

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1729

Dissolved Oxygen. The Narrows Cross-section between Fort Wadsworth, S. I. and Fort Lafayette. August 9, 1911.

High water at Governors Island at 7.42 a.m. Low water at 2.07 p.m.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "	Feet below surface				c.c. per litre	Percent aturation
876	9.40	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	1	Ebb	23	28	4.00	73
877	9.42	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	40	Ebb	22	22	4.26	77
878	9.44	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	75	Ebb	22	22	4.26	77
879	9.50	Midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	23	29	4.09	74
880	9.52	Midway between forts	Lat 40 36 25 Long 74 02 49	40	Ebb	22	22	4.39	80
881	9.54	Midway between forts	Lat 40 36 25 Long 74 02 48	75	Ebb	22	22	4.39	80
882	10.00	800 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 27	1	Ebb	23	29	4.12	75
883	10.02	800 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 27	40	Ebb	22	22	4.42	80
884	10.04	800 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 27	75	Ebb	22	22	4.42	80
885	11.40	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	1	Ebb	23	29	3.42	62
886	11.42	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	40	Ebb	22	22	3.72	68
887	11.44	800 feet off Fort Wadsworth	Lat 40 36 22 Long 74 02 09	75	Ebb	22	22	3.72	68
888	12.00	Midway between forts	Lat 40 36 25 Long 74 02 49	1	Ebb	23	29	3.57	65
889	12.02	Midway between forts	Lat 40 36 25 Long 74 02 48	40	Ebb	22	24	3.70	67

Dissolved Oxygen. The Narrows Cross-section between Fort Wadsworth, S. I. and Fort Lafayette. (Continued.) August 9, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
890	12.04	Midway between forts	Lat 40 36 25 Long 74 02 48	75	Ebb	22	24	3.70	67
891	12.10	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	1	Ebb	23	28	3.53	64
892	12.12	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	40	Ebb	22	24	3.83	70
893	12.14	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	75	Ebb	22	24	3.83	70
894	1.10	500 feet off Fort Wadsworth	Lat 40 36 22 Long 74 03 08	1	Ebb	23.5	28	3.43	62
895	1.12	500 feet off Fort Wadsworth	Lat 40 36 22 Long 74 03 08	40	Ebb	23	24	3.72	68
896	1.14	500 feet off Fort Wadsworth	Lat 40 36 22 Long 74 03 08	75	Ebb	23	24	3.72	68
897	1.20	Midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	23.5	28	3.57	65
898	1.22	Midway between forts	Lat 40 36 25 Long 74 02 48	40	Ebb	23	24	3.70	67
899	1.24	Midway between forts	Lat 40 36 25 Long 74 02 48	75	Ebb	23	24	3.70	67
900	1.30	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	1	Ebb	23.5	28	3.53	64
901	1.32	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	40	Ebb	23	24	3.68	64
902	1.34	500 feet off Fort Lafayette	Lat 40 36 28 Long 74 02 27	75	Ebb	23	24	3.68	67

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3522

Dissolved Oxygen.

Hudson River Cross-section from Pier A, Manhattan to C. R. R. of N. J. ferry, Jersey City. August 10, 1911.

High water at Governors Island at 8.23 a.m. Low water at 2.27 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
903	9.10	100 feet off pier A	Lat 40 42 16 Long 74 01 09	1	Flood	23	32	2.97	54
904	9.11	100 feet off pier A	Lat 40 42 16 Long 74 01 09	20	Flood	22	30	3.10	56
905	9.13	100 feet off pier A	Lat 40 42 16 Long 74 01 09	40	Flood	22	30	3.10	56
906	9.17	1/4 way across from pier A	Lat 40 42 17 Long 74 01 20	1	Flood	23	32	3.03	55
907	9.16	1/4 way across from pier A	Lat 40 42 17 Long 74 01 20	20	Flood	22	30	3.17	58
908	9.20	1/4 way across from pier A	Lat 40 42 17 Long 74 01 20	40	Flood	22	30	3.17	58
909	9.24	Midstream	Lat 40 42 19 Long 74 01 34	1	Flood	23	32	3.09	56
910	9.25	Midstream	Lat 40 42 19 Long 74 01 34	20	Flood	22	30	3.24	59
911	9.27	Midstream	Lat 40 42 19 Long 74 01 34	40	Flood	22	30	3.24	59
912	9.30	3/4 way across from pier A	Lat 40 42 21 Long 74 01 48	1	Flood	23	32	3.14	57
913	9.31	3/4 way across from pier A	Lat 40 42 21 Long 74 01 48	20	Flood	22	30	3.29	60
914	9.33	3/4 way across from pier A	Lat 40 42 21 Long 74 01 48	35	Flood	22	30	3.29	60
915	9.37	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	1	Flood	23	32	3.01	55

Dissolved Oxygen. Hudson River Cross-section from Pier A, Manhattan to C. R. R. of N. J. ferry, Jersey City. (Continued.)

August 10, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
916	9.38	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	20	Flood	22	30	3.15	57
917	9.40	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	28	Flood	22	30	3.15	57
918	11.10	100 feet off Pier A	Lat 40 42 16 Long 74 01 09	1	Ebb	23	34	2.70	49
919	11.11	100 feet off Pier A	Lat 40 42 16 Long 74 01 09	20	Ebb	22	32	2.81	51
920	11.13	100 feet off Pier A	Lat 40 42 16 Long 74 01 09	40	Ebb	22	32	2.81	51
921	11.17	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Ebb	23	34	2.90	53
922	11.18	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	20	Ebb	22	32	2.90	53
923	11.20	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	40	Ebb	22	32	2.90	53
924	11.24	Midstream	Lat 40 42 19 Long 74 01 34	1	Ebb	23	34	2.95	55
925	11.25	Midstream	Lat 40 42 19 Long 74 01 34	20	Ebb	22	32	2.95	55
926	11.27	Midstream	Lat 40 42 19 Long 74 01 34	40	Ebb	22	32	2.95	55
927	11.30	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Ebb	23	34	2.86	52
928	11.31	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	20	Ebb	22	32	3.00	55
929	11.33	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	35	Ebb	22	32	3.00	55

Dissolved Oxygen

Hudson River Cross-section from Pier A, Manhattan to C. R. R. R. of N. J. ferry, Jersey City. (Continued.)

August 10, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
930	11.37	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	1	Ebb	23	34	2.74	80
931	11.38	100 feet off C. R. R of N. J. ferry	Lat 40 42 22 Long 74 01 59	20	Ebb	22	32	2.88	82
932	11.40	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	28	Ebb	22	32	2.88	82
933	1.30	100 feet off Pier A	Lat 40 42 16 Lor 74 01 09	1	Ebb	23	36	2.70	49
934	1.31	100 feet off Pier A	Lat 40 42 16 Long 74 01 09	20	Ebb	22	32	2.81	81
935	1.33	100 feet off Pier A	Lat 40 42 16 Long 74 01 09	40	Ebb	22	32	2.81	81
936	1.37	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Ebb	23	36	2.76	80
937	1.38	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	20	Ebb	22	32	2.90	83
938	1.40	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	40	Ebb	22	32	2.90	83
939	1.44	Midstream	Lat 40 42 19 Long 74 01 34	1	Ebb	23	36	2.80	81
940	1.45	Midstream	Lat 40 42 19 Long 74 01 34	20	Ebb	22	32	2.95	85
941	1.47	Midstream	Lat 40 42 19 Long 74 01 34	40	Ebb	22	32	2.95	86
942	1.50	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Ebb	23	36	2.72	80
943	1.51	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	20	Ebb	22	32	2.86	82

Dissolved Oxygen.

Hudson River Cross-section from Pier A, Manhattan to C. R. R. of N. J. ferry, Jersey City. (Continued.)

August 10, 1911.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
944	1.51	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	35	Ebb	22	32	2.86	52
945	1.57	100 feet off C. R. R. of N. J. ferry	Lat 40 42 22 Long 74 01 59	1	Ebb	23	36	2.60	47
946	1.58	" " " " "	Lat 40 42 22 Long 74 01 59	20	Ebb	22	32	2.74	50
947	2.00	" " " " "	Lat 40 42 22 Long 74 01 59	28	Ebb	22	32	2.74	50

Ex. 94. p.80

Dissolved Oxygen. Gowanus Canal. August 10, 1911.

High water at Governors Island at 8.22 a.m. Low water at 2.27 p.m.

Sample No.	Hour	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
948	8.38	At Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	1	Ebb	28.8	80	0.81	15
949	8.36	At Hamilton Ave. bridge	Lat 40 40 17 Long 73 59 56	19	Ebb	28	80	1.92	34
950	8.48	At mouth, 28 St. Brooklyn	Lat 40 39 56 Long 74 00 28	1	Ebb	28.8	80	2.29	42
951	8.46	At mouth, 28 St. Brooklyn	Lat 40 39 55 Long 74 00 28	18	Ebb	28	80	2.29	42

Ex. 94. p.81

Dissolved Oxygen. Course from New York to New London, Conn., by Long Island Sound. August 17, 1911.

High water occurred at Governors Island, N.Y., at 12.30 P.M. Samples collected and tests made on boat Quadrant II.

Sample No.	Hour a.m.	Location of Samples Approximate		Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
982	8.00	East River, midstream, off East 42 St., N.Y.	Lat	40 44 47	1	Ebb	22	20	2.76	31
			Long	73 57 40						
983	8.01	East River, midstream, off East 42 St., N.Y.	Lat	40 44 47	20	Ebb	22	24	2.76	31
			Long	73 57 40						
984	8.03	East River, midstream, off East 42 St., N.Y.	Lat	40 44 47	40	Ebb	22	26	2.76	31
			Long	73 57 49						
985	6.00	East River midway between Glason Pt. and College Pt.	Lat	40 48 00	1	Ebb	22	24	2.98	73
			Long	73 51 11						
986	6.01	East River midway between Glason Pt. and College Pt.	Lat	40 48 00	20	Ebb	22	24	2.98	73
			Long	73 51 11						
987	6.03	East River midway between Glason Pt. and College Pt.	Lat	40 48 00	40	Ebb	22	24	2.98	73
			Long	73 51 11						
988	6.40	East River midway between Throgs Neck and Willets Pt.	Lat	40 48 00	1	Ebb	22	24	4.38	81
			Long	73 47 18						
989	6.41	East River midway between Throgs Neck and Willets Pt.	Lat	40 48 00	30	Ebb	22	22	4.39	81
			Long	73 47 18						
990	6.43	East River midway between Throgs Neck and Willets Pt.	Lat	40 48 00	60	Ebb	22	22	4.38	81
			Long	73 47 12						
991	7.18	Long Island Sound just North of SteppingStones lighthouse	Lat	40 49 38	1	Ebb	22	22	4.64	86
			Long	73 46 38						
992	7.16	Long Island Sound just north of SteppingStones lighthouse	Lat	40 49 38	20	Ebb	22	20	4.64	86
			Long	73 46 38						
993	7.18	Long Island Sound just north of SteppingStones lighthouse	Lat	40 49 38	40	Ebb	22	20	4.64	86
			Long	73 46 38						

Dissolved Oxygen. Course from New York to New London, Conn., by Long Island Sound. (Continued.) August 17, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
			o	'	"						
964	7.45	Long Island Sound, just south of Execution Rocks lighthouse	Lat 40	52	30	1	Ebb	22	20	5.22	97
			Long 73	44	15						
965	7.46	Long Island Sound, just south of Execution Rocks lighthouse	Lat 40	52	30	20	Ebb	21.5	20	5.22	97
			Long 73	44	15						
966	7.48	Long Island Sound, just south of Execution Rocks lighthouse	Lat 40	52	30	35	Ebb	21.5	20	5.22	97
			Long 73	44	15						
967	8.20	Long Island Sound, 1 mile north of Matinicock Point, L. I.	Lat 40	54	55	1	Ebb	22	20	5.40	100
			Long 73	38	10						
968	8.21	Long Island Sound, 1 mile north of Matinicock Point, L. I.	Lat 40	54	55	25	Ebb	21.5	20	5.40	100
			Long 73	38	10						
969	8.23	Long Island Sound, 1 mile north of Matinicock Point, L. I.	Lat 40	54	55	50	Ebb	21.5	20	5.40	100
			Long 73	38	10						
970	9.20	Long Island Sound, just north of bell buoy off Lloyd Point, L. I.	Lat 41	57	45	1	Ebb	22	20	5.40	100
			Long 73	29	15						
971	9.21	Long Island Sound, just north of bell buoy off Lloyd Point, L. I.	Lat 41	57	45	25	Ebb	21.5	20	5.40	100
			Long 73	29	15						
972	9.23	Long Island Sound, just north of bell buoy off Lloyd Point, L.I.	Lat 41	57	45	50	Ebb	21.5	20	5.40	100
			Long 73	29	15						
973	9.50	Long Island Sound, near red and black buoy off Eaton's Pt. L. I.	Lat 41	58	45	1	Ebb	22	20	5.40	100
			Long 73	24	40						
974	9.51	Long Island Sound, near red and black buoy off Eaton's Pt. L. I.	Lat 41	58	45	20	Ebb	21.5	20	5.40	100
			Long 73	24	40						
975	9.53	Long Island Sound, near red and black buoy off Eaton's pt. L.I.	Lat 41	58	45	40	Ebb	21.5	20	5.40	100
			Long 73	24	40						
976	11.45	Long Island Sound, by red buoy near Shatford Shoals lighthouse	Lat 41	03	15	1	Flood	21.5	16	5.40	100
			Long 73	06	10						
977	11.46	Long Island Sound, by red buoy near Shatford Shoals lighthouse	Lat 41	03	15	20	Flood	21	16	5.40	100
			Long 73	06	10						
978	11.48	Long Island Sound, by red buoy near Shatford Shoals lighthouse	Lat 41	03	15	40	Flood	21	16	5.40	100
			Long 73	06	10						

Dissolved Oxygen. Course from New York to New London, Conn., by Long Island Sound. (Continued.) August 17, 1911.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
979	12.45	Long Island Sound, 7 miles north of Rocky Pt. between Miller's and Hallock's landing	Lat 41 04 00 Long 72 57 25	1	Flood	21.5	16	5.40	100
980	12.46	Long Island Sound, 7 miles north of Rocky Pt. between Miller's and Hallock's landing	Lat 41 04 00 Long 72 57 25	40	Flood	21	16	5.40	100
981	12.48	Long Island Sound, 7 miles north of Rocky Pt. between Miller's and Hallock's landing	Lat 41 04 00 Long 72 57 25	80	Flood	21	16	5.40	100
982	2.30	Long Island Sound, 4 miles south of Falkner Island, Conn.	Lat 41 09 15 Long 72 39 00	1	Flood	21.5	16	5.40	100
983	2.31	Long Island Sound, 4 miles south of Falkner Island, Conn.	Lat 41 09 15 Long 72 39 00	40	Flood	21	16	5.40	100
984	2.33	Long Island Sound, 4 miles south of Falkner Island, Conn.	Lat 41 09 15 Long 72 39 00	80	Flood	21	16	5.40	100
985	4.25	Long Island Sound near Cornfield Point lightship	Lat 41 12 40 Long 72 22 40	1	Flood	21	11	5.40	100
986	4.26	Long Island Sound near Cornfield Point lightship	Lat 41 12 40 Long 72 22 40	50	Flood	20.5	10	5.40	100
987	4.28	Long Island Sound near Cornfield Point lightship	Lat 41 12 40 Long 72 22 40	00	Flood	20.5	10	5.40	100
988	6.00	Long Island Sound near Bartlett Reef lightship off New London, Conn.	Lat 41 16 15 Long 72 08 50	1	Ebb	21	10	5.40	100
989	6.01	Long Island Sound near Bartlett Reef lightship off New London, Conn.	Lat 41 16 15 Long 72 08 50	25	Ebb	20.5	10	5.40	100
990	6.03	Long Island Sound near Bartlett Reef lightship off New London, Conn.	Lat 41 16 15 Long 72 08 50	50	Ebb	20.5	10	5.40	100

Dissolved Oxygen. Course from New London, Conn. to Vineyard Haven, Mass. August 18, 1911.

High water at New London at 3.13 a.m. Left New London 5.25 a.m. on boat Quadrant II.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
991	6.15	Fisher Island sound, by Ram Island lightship	Lat 41 18 00 Long 71 56 35	1	Ebb	20	8	5.40	100
992	6.16	Fisher Island sound, by Ram Island lightship	Lat 41 18 00 Long 71 56 35	25	Ebb	20	8	5.40	100
993	6.18	Fisher Island sound, by Ram Island lightship	Lat 41 18 00 Long 71 56 35	50	Ebb	20	8	5.40	100
994	6.50	Block Island sound by bell buoy just off Watch Hill Point	Lat 41 17 45 Long 71 51 50	1	Ebb	20	8	5.40	100
995	6.51	Block Island sound by bell buoy just off Watch Hill Point	Lat 41 17 45 Long 71 51 50	20	Ebb	20	8	5.40	100
996	6.53	Block Island sound by bell buoy just off Watch Hill Point	Lat 41 17 45 Long 71 51 50	40	Ebb	20	8	5.40	100
997	7.40	Block Island sound, 1 mile south of Noyes Point	Lat 41 18 45 Long 71 45 00	1	Ebb	20	8	5.40	100
998	7.41	Block Island sound, 1 mile south of Noyes Point	Lat 41 18 45 Long 71 45 00	30	Ebb	20	8	5.40	100
999	7.43	Block Island sound, 1 mile south of Noyes Point	Lat 41 18 45 Long 71 45 00	60	Ebb	20	8	5.40	100
1000	9.00	Atlantic Ocean by whistling buoy off Point Judith, R. I.	Lat 41 20 30 Long 71 28 30	1	Ebb	20	8	5.40	100
1001	9.01	Atlantic Ocean by whistling buoy off Point Judith, R. I.	Lat 41 20 30 Long 71 28 30	20	Ebb	20	8	5.40	100
1002	9.03	Atlantic Ocean by whistling buoy off Point Judith, R. I.	Lat 41 20 30 Long 71 28 30	40	Ebb	20	8	5.40	100
1003	11.50	Atlantic Ocean near Vineyard Sound lightship	Lat 41 22 40 Long 71 00 00	1	Ebb	19.5	6	5.40	100
1004	11.51	Atlantic Ocean near Vineyard Sound lightship	Lat 41 22 40 Long 71 00 00	40	Ebb	19.5	6	5.40	100

Dissolved Oxygen.

Course from New London, Conn. to Vineyard Haven, Mass. (continued) August 18, 1911.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1005	11.53 p.m.	Atlantic Ocean near Vineyard Sound lightship	Lat 41 22 40 Long 71 00 00	30	Ebb	19.5	6	5.40	100
1006	1.00	Vineyard Sound by bell buoy north of Gay Head, Marthas Vineyard	Lat 71 24 15 Long 70 51 20	1	Ebb	19.5	6	5.40	100
1007	1.01	Vineyard Sound, by bell buoy north of Gay Head, Marthas Vineyard	Lat 71 24 15 Long 70 51 20	25	Ebb	19.5	6	5.40	100
1008	1.03	Vineyard Sound by bell buoy north of Gay Head, Marthas Vineyard	lat 71 24 15 Long 70 51 20	50	Ebb	19.5	6	5.40	100
1009	2.00	Vineyard Sound by bell buoy off Nobska Pt. near Woods Hole	Lat 41 30 20 Long 70 38 40	1	Flood	20	6	5.40	100
1010	2.01	Vineyard Sound by bell buoy off Nobska Pt. near Woods Hole	Lat 41 30 20 Long 70 38 40	30	Flood	20	6	5.40	100
1011	2.03	Vineyard Sound by bell buoy off Nobska Pt. near Woods Hole	Lat 41 30 20 Long 70 38 40	60	Flood	20	6	5.40	100
1012	2.30	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	1	Flood	20.5	6	5.40	100
1013	2.31	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	30	Flood	20	6	5.40	100
1014	2.33	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	60	Flood	20	6	5.40	100
1015	3.00	At Lords Wharf, Vineyard Haven, Mass.	Lat 41 27 15 Long 70 36 00	1	Flood	21	6	5.40	100
1016	3.01	At Lords Wharf, Vineyard Haven, Mass.	Lat 41 27 15 Long 70 36 00	10	Flood	21	6	5.40	100

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2531-2

Dissolved Oxygen. Course from Vineyard, Mass. to Provincetown, Mass. around Cape Cod. August 20, 1911.

High water at Vineyard Haven at 7.30 a.m. Very high N. W. wind, amounting to a gale, blew from 10 p.m. August 18 to 8 p.m. August 19 Held boat in Vineyard Haven harbor.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.c	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1017	5.00	At Lords Wharf, Vineyard Haven	Lat 41 27 15 Long 70 36 00	1	Flood	20.5	6	5.40	100
1018	5.01	At Lords Wharf, Vineyard Haven	Lat 41 27 15 Long 70 36 00	10	Flood	20.5	6	5.40	100
1019	5.10	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	1	Flood	20.5	6	5.40	100
1020	5.11	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	20	Flood	20	6	5.40	100
1021	5.13	Vineyard Haven, at entrance to harbor	Lat 41 28 45 Long 70 35 25	60	Flood	20	6	5.40	100
1022	5.23	Vineyard Sound, 1/2 mile off dock at Oak Bluffs (Cottage City)	Lat 41 28 20 Long 70 34 45	1	Flood	20.5	6	5.40	100
1023	5.24	Vineyard Sound, 1/2 mile off dock at Oak Bluffs (Cottage City)	Lat 41 28 20 Long 70 34 45	20	Flood	20	6	5.40	100
1024	5.26	Vineyard Sound, 1/2 mile off dock at Oak Bluffs (Cottage City)	Lat 41 28 20 Long 70 34 45	45	Flood	20	6	5.40	100
1025	6.00	Atlantic Ocean near Hedge Fence lightship	Lat 41 28 20 Long 70 29 00	1	Flood	19.5	4	5.40	100
1026	6.01	Atlantic Ocean near Hedge Fence lightship	Lat 41 28 20 Long 70 29 00	25	Flood	19	4	5.40	100
1027	6.03	Atlantic Ocean near Hedge Fence lightship	Lat 41 28 20 Long 70 29 00	50	Flood	19	4	5.40	100

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1916

Sample No.	Hour a.m.	Location of Sample: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
1038	7.00	Atlantic Ocean near Cross Rip lightship	Lat 41 26 30 Long 70 17 25	1	Flood	19.8	4	5.40	100
1039	7.01	Atlantic Ocean near Cross Rip lightship	Lat 41 26 30 Long 70 17 25	25	Flood	19	4	5.40	100
1040	7.02	Atlantic Ocean near Cross Rip lightship	Lat 41 26 30 Long 70 17 25	50	Flood	17	4	5.40	100
1041	8.20	Atlantic Ocean near Handkerchief lightship	Lat 41 29 15 Long 70 04 00	1	Ebb	18	4	5.84	100
1042	8.21	Atlantic Ocean near Handkerchief lightship	Lat 41 29 15 Long 70 04 00	18	Ebb	18	4	5.84	100
1043	8.23	Atlantic Ocean near Handkerchief lightship	Lat 41 29 15 Long 70 04 00	30	Ebb	18	4	5.84	100
1034	9.10	Atlantic Ocean near Shovelfull lightship off Monomoy Beach, Cape Cod	Lat 41 32 40 Long 69 59 40	1	Ebb	18	4	5.84	100
1035	9.11	Atlantic Ocean near Shovelfull lightship off Monomoy Beach, Cape Cod	Lat 41 32 40 Long 69 59 40	25	Ebb	17	4	5.84	100
1036	9.13	Atlantic Ocean near Shovelfull lightship off Monomoy Beach, Cape Cod	Lat 41 32 40 Long 69 59 40	50	Ebb	17	4	5.84	100
1037	9.45	Atlantic Ocean near Pollock Rip lightship	Lat 41 32 00 Long 69 54 40	1	Ebb	17	4	5.68	100
1038	9.46	Atlantic Ocean near Pollock Rip lightship	Lat 41 32 00 Long 69 54 40	12	Ebb	17	4	5.68	100
1039	9.48	Atlantic Ocean near Pollock Rip lightship	Lat 41 32 00 Long 69 54 40	50	Ebb	17	4	5.68	100
1040	10.15	Atlantic Ocean near Pollock Rip Shoals lightship	Lat 41 26 35 Long 69 53 50	1	Ebb	17	4	5.68	100

Sample No.	Hour e.s.	Location of Samples: Approximate		Exact °	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	C.C. per litre	Percent saturation
1041	10.16	Atlantic Ocean near Pollock Rip Shoals lightship	Lat	41	36	36	20	Ebb	17	4	5.68	100
			Long	69	53	50						
1042	10.18	Atlantic Ocean near Pollock Rip Shoals lightship	Lat	41	36	36	40	Ebb	17	4	5.68	100
			Long	69	53	50						
1043	11.18	Atlantic Ocean, 4 miles east of Chatham lighthouse	Lat	41	41	00	1	Ebb	17	4	5.69	100
			Long	69	52	10						
1044	11.16	Atlantic Ocean, 4 miles east of Chatham lighthouse	Lat	41	41	00	25	Ebb	17	4	5.68	100
			Long	69	52	10						
1045	11.18	Atlantic Ocean, 4 miles east of Chatham lighthouse	Lat	41	41	00	50	Ebb	17	4	5.68	100
			Long	69	52	10						
1046	12.48	Atlantic Ocean, 1 1/2 miles off Nauset lighthouses, Cape Cod	Lat	41	51	50	1	Ebb	17	4	5.68	100
			Long	69	55	28						
1047	12.46	Atlantic Ocean, 1 1/2 miles off Nauset lighthouses, Cape Cod	Lat	41	51	50	35	Ebb	17	4	5.68	100
			Long	69	55	28						
1048	12.48	Atlantic Ocean, 1 1/2 miles off Nauset lighthouses, Cape Cod	Lat	41	51	50	70	Ebb	17	4	5.68	100
			Long	69	55	28						
1049	8.30	Atlantic Ocean, 1 mile off Highland light, Cape Cod	Lat	42	02	48	1	Flood	17	4	5.68	100
			Long	70	02	36						
1050	8.31	Atlantic Ocean, 1 mile off Highland light, Cape Cod	Lat	42	02	48	30	Flood	17	4	5.69	100
			Long	70	02	36						
1051	8.33	Atlantic Ocean, 1 mile off Highland light, Cape Cod	Lat	42	02	48	60	Flood	17	4	5.68	100
			Long	70	02	36						
1052	3.30	Cape Cod bay by white buoy off Race Point, Provincetown	Lat	42	02	48	1	Flood	18	6	5.68	100
			Long	70	15	08						
1053	3.32	Cape Cod bay by white buoy off Race Point, Provincetown	Lat	42	02	48	80	Flood	17	6	5.68	100
			Long	70	15	08						
1054	3.34	Cape Cod bay by white buoy off Race Point, Provincetown	Lat	42	02	48	100	Flood	17	6	5.68	100
			Long	70	15	08						
1055	4.18	Cape Cod bay by bell buoy off Long Point light, just outside Provincetown	Lat	42	01	50	1	Flood	18	6	5.68	100
			Long	70	09	48						

Dissolved Oxygen. Course from Vineyard Haven, Mass. to Provincetown, Mass. around Cape Cod. (Continued.) August 20. 1911.

Sample No.	Hour p.m.	Location of Samples						Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact				Feet below surface				C.C. per litre	Percent saturation
				°	'	"						
1056	4.15	Cape Cod Bay by bell buoy off Long Point light, just outside Provincetown	Lat	42	01	50	30	Flood	17	6	5.68	100
			Long	70	09	45						
1057	4.18	Cape Cod Bay by bell buoy off Long Point light, just outside Provincetown	Lat	42	01	50	60	Flood	17	6	5.68	100
			Long	70	09	45						

Ex. 94. p. 90.

Dissolved Oxygen.

Course from Provincetown to Boston, Mass.

High water at Provincetown at 8.25 a.m.

August 21, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1058	5.00	Provincetown harbor 1 mile north of Long Point lighthouse	Lat 42 02 45 Long 70 10 20	1	Flood	18.5	6	5.68	100
1059	5.01	Provincetown harbor 1 mile north of Long Point lighthouse	Lat 42 02 45 Long 70 10 20	20	Flood	18	5	5.68	100
1060	5.03	Provincetown harbor 1 mile north of Long Point lighthouse	Lat 42 02 45 Long 70 10 20	40	Flood	18	5	5.68	100
1061	6.05	Cape Cod bay by white buoy off Race Point outside Provincetown	Lat 42 02 45 Long 70 15 05	1	Flood	18	5	5.68	100
1062	6.06	Cape Cod bay by white buoy off Race Point outside Provincetown	Lat 42 02 45 Long 70 15 05	50	Flood	18	4	5.68	100
1063	6.08	Cape Cod bay by white buoy off Race Point outside Provincetown	Lat 42 02 45 Long 70 15 05	100	Flood	18	4	5.68	100
1064	6.45	Massachusetts bay, 2 miles N. W. of Race Point, Cape Cod	Lat 42 04 35 Long 70 16 35	1	Flood	18.5	4	5.68	100
1065	6.46	Massachusetts bay, 2 miles N. W. of Race Point, Cape Cod	Lat 42 04 35 Long 70 16 35	50	Flood	18	4	5.68	100
1066	6.48	Massachusetts bay, 2 miles N. W. of Race Point, Cape Cod	Lat 42 04 35 Long 70 16 35	100	Flood	18	4	5.68	100
1067	10.00	Massachusetts bay by black buoy 2 miles off Minots ledge light	Lat 42 16 40 Long 70 42 20	1	Ebb	18.5	6	5.54	100
1068	10.01	Massachusetts bay by black buoy 2 miles off Minots ledge light	Lat 42 16 40 Long 70 42 20	25	Ebb	18.5	6	5.54	100
1069	10.03	Massachusetts bay by black buoy 2 miles off Minots ledge light	Lat 42 16 40 Long 70 42 20	50	Ebb	18.5	6	5.54	100
1070	11.00	Massachusetts bay, 1 mile S. E. of Boston light	Lat 42 19 15 Long 70 52 25	1	Ebb	18.5	6	5.54	100
1071	11.01	Massachusetts bay, 1 mile S. E. of Boston light	Lat 42 19 15 Long 70 52 25	20	Ebb	18.5	6	5.54	100
1072	11.03	Massachusetts bay, 1 mile S. E. of Boston light	Lat 42 19 15 Long 70 52 25	40	Ebb	18.5	6	5.54	100

Dissolved Oxygen. Course from Provincetown to Boston, Mass.

August 21, 1911.

High water at Boston at 8.35 a.m. Tied up in Charles river.

Sample No.	Hour a.m.	Location of Samples: Approximate		Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1073	11.20	Boston harbor, The Narrows between Lovells Is. and Gallups Island	Lat Long	42 19 35 70 56 55	1	Ebb	19.5	6	5.47	100
1074	11.21	Boston harbor, The Narrows between Lovells Is. and Gallups Island	Lat Long	42 19 35 70 56 55	15	Ebb	19	6	5.47	100
1075	11.23	Boston harbor, The Narrows between Lovells Is. and Gallups Island	Lat Long	42 19 35 70 56 55	30	Ebb	19	6	5.47	100
1076	11.45	Midway between Governors Island and Castle Island	Lat Long	42 20 42 71 00 42	1	Ebb	19.5	6	5.11	95
1077	11.46	Midway between Governors Island and Castle Island	Lat Long	42 20 42 71 00 42	15	Ebb	19	6	5.28	98
1078	11.48	Midway between Governors Island and Castle Island	Lat Long	42 20 42 71 00 42	30	Ebb	19	6	5.28	98
1079	12.15 p.m.	Midway between East Boston docks and entrance to South bay	Lat Long	42 21 39 71 02 35	1	Ebb	19.5	6	4.93	91
1080	12.16	Midway between East Boston docks and entrance to South bay	Lat Long	42 21 39 71 02 35	15	Ebb	19	6	5.07	94
1081	12.17	Midway between East Boston docks and entrance to South bay	Lat Long	42 21 39 71 02 35	30	Ebb	19	6	5.07	94
1082	12.40	Charles river, near mouth, just below last drawbridge	Lat Long	42 22 07 71 03 30	1	Ebb	19.5	10	2.27	42
1083	12.41	Charles river, near mouth, just below last drawbridge	Lat Long	42 22 07 71 03 30	10	Ebb	19	8	3.41	63
1084	12.43	Charles river, near mouth, just below last drawbridge	Lat Long	42 22 07 71 03 30						

Dissolved Oxygen. Boston Harbor. Inner harbor to South Channel in outer harbor. August 23, 1911.

High water at Boston at 10.30 a.m. Low water at 4.30 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1085	9.10	Boston inner harbor midway between East Boston docks and entrance to South Bay, Boston	Lat 42 21 39 Long 71 02 35	1	Flood	19.5	6	5.40	100
1086	9.11	Boston inner harbor midway between East Boston docks and entrance to South Bay, Boston	Lat 42 21 39 Long 71 02 35	15	Flood	19.5	6	5.40	100
1087	9.13	Boston inner harbor midway between East Boston docks and entrance to South Bay, Boston	Lat 42 21 39 Long 71 02 36	30	Flood	19.5	6	5.40	100
1088	9.22	Boston inner harbor by red buoy 10 midway between Governors Island and East Boston docks	Lat 42 21 36 Long 71 01 10	1	Flood	19.5	6	5.40	100
1089	9.24	Boston inner harbor by red buoy 10 midway between Governors Island and East Boston docks	Lat 42 21 36 Long 71 01 10	10	Flood	19	6	5.40	100
1090	9.26	Boston inner harbor by red buoy 10 midway between Governors Island and East Boston docks	Lat 42 21 36 Long 71 01 10	15	Flood	19	6	5.40	100
1091	9.36	Boston inner harbor midway between Governors Is. and Castle Island	Lat 42 20 42 Long 71 00 42	1	Flood	19.5	6	5.28	98
1092	9.37	Boston inner harbor midway between Governors Is. and Castle Island	Lat 42 21 42 Long 71 00 42	15	Flood	19	6	5.40	100
1093	9.39	Boston inner harbor midway between Governors Is. and Castle Island	Lat 42 21 42 Long 71 00 42	30	Flood	19	6	5.40	100
1094	9.55	Boston outer harbor midway between Deer Is. light and Governors Is.	Lat 42 20 36 Long 70 58 48	1	Flood	19.5	6	5.40	100
1095	9.56	Boston outer harbor midway between Deer Is. light and Governors Is.	Lat 42 20 36 Long 70 58 48	10	Flood	19	6	5.40	100

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 25,238

Sample No.	Hour A.M.	Location of Samples: Approximate	Exact:	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1096	9.50	Boston outer harbor midway between Deer Is. light and Governors Is.	Lat	42	20	36	20	Flood	19	6	5.40	100
			Long	70	58	45						
1097	10.18	Boston outer harbor midway between Deer Is. light and Long Island light	Lat	42	20	36	1	Flood	19.5	6	5.42	100
			Long	70	57	13						
1098	10.19	Boston outer harbor midway between Deer Is. light and Long Is. light	Lat	42	20	06	30	Flood	19	4	5.42	100
			Long	70	57	13						
1099	10.21	Boston outer harbor midway between Deer Is. light and Long Is. light	Lat	42	20	06	60	Flood	19	4	5.42	100
			Long	70	57	13						
1100	10.40	Boston outer harbor by gas buoy 8, entrance to South Channel (E. of Lovells Island)	Lat	42	20	34	1	Flood	18	4	5.47	100
			Long	70	56	04						
1101	10.41	Boston outer harbor by gas buoy 8, entrance to South Channel (E. of Lovells Island)	Lat	42	20	34	30	Flood	17	4	5.47	100
			Long	70	56	04						
1102	10.45 p.m.	Boston outer harbor by gas buoy 8, entrance to South Channel (E. of Lovells Island)	Lat	42	20	34	40	Flood	17	4	5.47	100
			Long	70	56	04						
1103	8.00	Boston inner harbor midway between East Boston docks and entrance to South bay, Boston	Lat	42	21	39	1	Ebb	19.5	6	4.51	84
			Long	71	02	36						
1104	8.01	Boston inner harbor midway between East Boston docks and entrance to South bay, Boston	Lat	42	21	39	15	Ebb	19	6	4.65	86
			Long	71	02	36						
1105	8.08	Boston inner harbor midway between East Boston docks and entrance to South bay, Boston	Lat	42	21	39	30	Ebb	19	6	4.65	86
			Long	71	02	35						
1106	8.15	Boston inner harbor by red buoy 10 midway between Governors Island and East Boston docks	Lat	42	21	38	1	Ebb	19.6	6	4.98	91
			Long	71	01	10						

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3540

Dissolved Oxygen — Boston Harbor-Inner harbor to South channel in outer harbor — August 28, 1911

High water at Boston 10.30 a. m. Low water at 4.30 p. m.

Sample No.	Hour p.m.	Location of Sample: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1107	3.14	Boston inner harbor by red buoy 10 midway between Governors Is. and East Boston docks	Lat 42 21 28 Long 71 01 10	10	Ebb	19	6	8.07	94
1108	3.16	" "	Lat 42 21 28 Long 71 01 10	28	Ebb	19	6	8.07	94
1109	3.26	Midway between Governors Is. and Castle Is.	Lat 42 20 48 Long 71 00 48	1	Ebb	19.8	6	8.00	93
1110	3.29	" "	Lat 42 20 42 Long 71 00 48	18	Ebb	19	6	8.14	98
1111	3.29	" "	Lat 42 20 42 Long 71 00 48	30	Ebb	19	6	8.14	98
1112	3.45	Boston outer harbor-midway between Deer Island light and Governors Island	Lat 42 20 36 Long 70 58 48	1	Ebb	19.8	6	8.11	98
1113	3.46	" "	Lat 42 20 36 Long 70 58 48	10	Ebb	19	6	8.06	97
1114	3.49	" "	Lat 42 20 36 Long 70 58 48	30	Ebb	19	6	8.06	97
1115	4.10	Boston outer harbor-midway between Deer Island light and Long Island light	Lat 42 20 06 Long 70 57 13	1	Ebb	19.8	6	8.40	100
1116	4.11	" "	Lat 42 20 06 Long 70 57 13	30	Ebb	19	6	8.40	100
1117	4.15	" "	Lat 42 20 06 Long 70 57 13	60	Ebb	19	6	8.40	100
1118	4.20	Boston outer harbor-by gas buoy 8 at entrance to South channel	Lat 42 20 34 Long 70 56 04	1	Ebb	19.5	6	8.47	100
1119	4.21	" "	Lat 42 20 34 Long 70 56 04	20	Ebb	19	6	8.47	100
1120	4.23	" "	Lat 42 20 34 Long 70 56 04	40	Ebb	19	6	8.47	100

Dissolved Oxygen — Boston Harbor-from inner harbor to South channel in outer harbor — August 25, 1911

High water at Boston 12.10 p. m.

Sample No.	Hour a.m.	Location of Samples: Approximate		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1121	9.00	Boston inner harbor-midway between East Boston docks and entrance to South bay	Lat 42 21 39 Long 71 03 36	1	Flood	19.8	6	5.30	98
1122	9.01	"	" Lat 42 21 39 Long 71 02 35	19	Flood	19	6	5.26	97
1123	9.03	"	" Lat 42 21 39 Long 71 02 35	50	Flood	19	6	5.26	97
1124	9.13	Boston inner harbor-by red buoy 10-midway between Governors Island and East Boston docks	Lat 42 21 38 Long 71 01 10	1	Flood	19.8	6	5.22	97
1125	9.14	"	" Lat 42 21 38 Long 71 01 10	10	Flood	19	6	5.34	99
1126	9.16	"	" Lat 42 21 38 Long 71 01 10	15	Flood	19	6	5.30	99
1127	9.26	Boston inner harbor-midway between Governors Island and Castle Island	Lat 42 20 42 Long 71 00 42	1	Flood	19.5	6	5.11	95
1128	9.27	"	" Lat 42 20 42 Long 71 00 42	18	Flood	19	6	5.40	100
1129	9.29	"	" Lat 42 20 42 Long 71 00 42	30	Flood	19	6	5.40	100

Dissolved Oxygen — Boston harbor-Inner harbor to South channel in outer harbor — August 25, 1911

(Continued)

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1130	9.45	Boston outer harbor-midway between Deer Island light and Governors Island	Lat 42 20 36 Long 70 58 45	1	Flood	19.5	6	5.42	100
1131	9.46	" "	Lat 42 20 36 Long 70 58 45	10	Flood	19	6	5.42	100
1132	9.48	" "	Lat 42 20 36 Long 70 58 45	20	Flood	19	6	5.42	100
1133	10.10	Boston outer harbor-midway between Deer Island light and Long Island light.	Lat 42 20 06 Long 70 57 13	1	Flood	19.5	6	5.40	100
1134	10.11	" "	Lat 42 20 06 Long 70 57 13	30	Flood	19	4	5.40	100
1135	10.13	" "	Lat 42 20 06 Long 70 57 13	60	Flood	19	4	5.40	100
1136	10.30	Boston outer harbor-by gas buoy 8 entrance to South channel	Lat 42 20 34 Long 70 56 04	1	Flood	19.5	4	5.42	100
1137	10.31	" "	Lat 42 20 34 Long 70 56 04	15	Flood	19	4	5.42	100
1138	10.33	" "	Lat 42 20 34 Long 70 56 04	30	Flood	19	4	5.42	100

Dissolved Oxygen — Boston harbor-from inner harbor to South Channel in outer harbor — August 25, 1911

High water at Boston at 12.10 p.m. Low water at 6.00 p.m. Rain all day.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact: o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1139	3.00	Boston inner harbor-midway between East Boston docks and entrance to South bay, Boston	Lat 42 21 39 Long 71 02 35	1	Ebb	19	6	4.65	86
1140	3.01	" "	Lat 42 21 39 Long 71 02 35	15	Ebb	19	6	4.78	89
1141	3.03	" "	Lat 42 21 39 Long 71 02 35	30	Ebb	19	6	4.78	89
1142	3.13	Boston inner harbor-by red buoy 10-midway between Governors Island and East Boston docks	Lat 42 21 35 Long 71 01 10	1	Ebb	19	6	5.07	94
1143	3.14	" "	Lat 42 21 35 Long 71 01 10	10	Ebb	19	6	5.22	97
1144	3.16	" "	Lat 42 21 35 Long 71 01 10	15	Ebb	19	6	5.22	97
1145	3.26	Boston inner harbor-midway between Governors Island and Castle Island	Lat 42 20 42 Long 71 00 42	1	Ebb	19	6	5.07	94
1146	3.27	" "	Lat 42 20 42 Long 71 00 42	15	Ebb	19	6	5.22	97
1147	3.29	" "	Lat 42 20 42 Long 71 00 42	30	Ebb	19	6	5.22	97
1148	3.48	Boston outer harbor-midway between Deer Island light and Governors Island	Lat 42 20 36 Long 70 58 45	1	Ebb	19	6	5.26	97
1149	3.49	" "	Lat 42 20 36 Long 70 58 45	10	Ebb	19	6	5.40	100
1150	3.51	" "	Lat 42 20 36 Long 70 58 45	20	Ebb	19	6	5.40	100

Dissolved Oxygen — Boston harbor-from inner harbor to South Channel in outer harbor — August 25, 1911
(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1151	4.12	Boston outer harbor-midway between Deer Island Light and Governors Island	Lat 42 20 06 Long 70 57 13	1	Ebb	19	6	5.40	100
1152	4.18	" "	Lat 42 20 06 Long 70 57 13	30	Ebb	19	6	5.40	100
1153	4.16	" "	Lat 42 20 06 Long 70 57 13	60	Ebb	19	6	5.40	100
1154	4.30	Boston outer harbor-by gas buoy 8 at entrance to South channel	Lat 42 20 34 Long 70 56 04	1	Ebb	19	6	5.42	100
1155	4.21	" "	Lat 42 20 34 Long 70 56 04	15	Ebb	19	4	5.42	100
1156	4.33	" "	Lat 42 20 34 Long 70 56 04	30	Ebb	19	4	5.42	100

Dissolved Oxygen — Boston inner harbor at Charles River. August 28, 1911

High water at Boston at 2.26 p. m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C.	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1157	8.46	Charles river-midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	1	Ebb	20	32	1.79	31
1158	8.46	Charles river-midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	15	Ebb	19.5	24	2.39	43
1159	8.46	Charles river-midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	30	Ebb	19.5	24	2.39	43
1160	9.00	Inner harbor off mouth of Charles river midway to East Boston	Lat 42 22 15 Long 71 02 55	1	Flood	19.5	18	3.84	66
1161	9.01	" "	Lat 42 22 16 Long 71 02 55	15	Flood	19	18	3.98	74
1162	9.03	" "	Lat 42 22 16 Long 71 02 55	30	Flood	19	18	3.98	74
1163	9.10	Inner harbor-midway between Charlestown and East boston-between Charles and Mystic rivers	Lat 42 22 36 Long 71 02 47	1	Flood	19.5	18	3.76	70
1164	9.11	" "	Lat 42 22 36 Long 71 02 47	15	Flood	19	10	3.89	72
1165	9.15	" "	Lat 42 22 36 Long 71 02 47	30	Flood	19	10	3.89	72
1166	9.20	Inner-harbor-off mouth of Chelsea river	Lat 42 23 09 Long 71 02 28	1	Flood	19.5	10	3.77	70
1167	9.21	Inner harbor-off mouth of Chelsea river	Lat 42 23 09 Long 71 02 28	15	Flood	19	8	4.06	75
1168	9.25	Inner harbor-off mouth of Chelsea river	Lat 42 23 09 Long 71 02 28	25	Flood	19	8	4.06	75
1169	9.30	Inner harbor-just below Mystic river bridge	Lat 42 23 06 Long 71 02 48	1	Flood	19.5	10	3.83	71
1170	9.31	Inner harbor-just below Mystic river bridge	Lat 42 23 06 Long 71 02 48	15	Flood	19	8	4.00	74
1171	9.33	Inner harbor-just below Mystic river bridge	Lat 42 23 06 Long 71 02 48	30	Flood	19	8	4.00	74

Dissolved Oxygen Boston inner harbor August 28,1911

(Continued)

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact				Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1172	9.40	Inner harbor-just off South branch of Mystic river	Lat	42	22	46	1	Flood	19.5	16	3.58	72
			Long	71	02	53						
1173	9.41	Inner harbor-just off South branch of Mystic river	Lat	42	22	46	16	Flood	19	8	4.18	77
			Long	71	02	53						
1174	9.42	Inner harbor-just off South branch of Mystic river	Lat	42	22	46	30	Flood	19	8	4.18	77
			Long	71	02	53						
1175	12.00	Charles river-midway between mouth and lowest bridge	Lat	42	22	15	1	Flood	19.5	32	2.03	36
			Long	71	03	18						
1176	12.01	Charles river-midway between mouth and lowest bridge	Lat	42	22	15	15	Flood	19.5	18	3.48	63
			Long	71	03	18						
1177	12.03	Charles river-midway between mouth and lowest bridge	Lat	42	22	15	30	Flood	19.5	18	3.48	63
			Long	71	03	18						

Dissolved Oxygen — Boston outer harbor in the vicinity of Deer Island light. — August 30, 1911

High water at Boston at 8.59 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1178	1.00	Boston outer harbor-midway between Deer Island light and Governors Island	Lat 42 20 26 Long 70 58 48	1	Flood	19	6	5.40	100
1179	1.01	" "	Lat 42 20 26 Long 70 58 48	10	Flood	19	6	5.40	100
1180	1.02	" "	Lat 42 20 26 Long 70 58 48	80	Flood	19	6	5.40	100
1181	2.50	50 feet south of Deer Is.light	Lat 42 20 22 Long 70 57 19	1	Ebb	19.5	10	5.07	98
1182	2.51	50 feet south of Deer Is.light	Lat 42 20 23 Long 70 57 17	12	Ebb	19	6	5.37	99
1183	2.00	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	1	Ebb	19.5	10	5.07	98
1184	2.01	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	50	Ebb	19	6	5.36	99
1185	2.02	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	60	Ebb	19	6	5.36	99
1186	2.12	500 feet southeast of Deer Is light	Lat 42 20 22 Long 70 57 12	1	Ebb	19.5	10	5.00	98
1187	2.13	500 feet southeast of Deer Is light	Lat 42 20 22 Long 70 57 12	50	Ebb	19	6	5.42	100
1188	2.15	500 feet southeast of Deer Is light	Lat 42 20 22 Long 70 57 12	60	Ebb	19	6	5.42	100
1189	2.20	1000 feet east of Deer Is light	Lat 42 20 26 Long 70 57 06	1	Ebb	19	6	5.40	100
1190	2.21	1000 feet east of Deer Is light	Lat 42 20 26 Long 70 57 06	50	Ebb	19	6	5.40	100
1191	2.22	1000 feet east of Deer Is light	Lat 42 20 26 Long 70 57 06	80	Ebb	19	6	5.40	100

(Continued)

Sample No.	Hour p.m.	Location of Sample — Approximate		Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent ature-tion
1192	3.30	Near buoy 8 inside South channel	Lat	42 20 34	1	Ebb	19	6	8.47	100
			Long	70 56 04						
1193	3.31	Near buoy 8 inside South channel	Lat	42 20 34	88	Ebb	19	6	8.47	100
			Long	70 56 04						
1194	3.35	Near buoy 8 inside South channel	Lat	42 20 34	80	Ebb	19	6	8.47	100
			Long	70 56 34						

PEOPLE OF STATE OF NEW YORK v. STATE OF NEW JERSEY. 9746

Dissolved Oxygen — Boston inner harbor and Charles river. — August 29, 1911

High water at Boston at 3.17 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: Lat / Long	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1195	9.00	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	1	Flood	20	26	2.27	41
1196	9.01	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	15	Flood	19.5	16	3.41	62
1197	9.03	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	30	Flood	19.5	16	3.41	62
1198	9.20	Inner harbor-midway between East Boston docks and entrance to South bay	Lat 42 21 39 Long 71 02 35	1	Flood	19.5	10	3.69	68
1199	9.21	" "	Lat 42 21 39 Long 71 02 35	15	Flood	19	6	4.26	80
1200	9.23	" "	Lat 42 21 39 Long 71 02 35	30	Flood	19	6	4.26	80
1201	9.33	Inner harbor-by buoy 10 between East Boston docks and Governors Island	Lat 42 21 35 Long 71 01 10	1	Flood	19.5	10	4.48	83
1202	9.34	" "	Lat 42 21 35 Long 71 01 10	10	Flood	19	6	4.83	90
1203	9.36	" "	Lat 42 21 35 Long 71 01 10	15	Flood	19	6	4.83	90
1204	9.51	Inner harbor-midway between Governors Island and Castle Is.	Lat 42 20 42 Long 71 00 42	1	Flood	19.5	10	4.64	86
1205	9.52	" "	Lat 42 20 42 Long 71 00 42	15	Flood	19	6	5.11	95
1206	9.54	" "	Lat 42 20 42 Long 71 00 42	30	Flood	19	6	5.11	95
1207	10.05	Outer harbor-midway between Governors Is and Deer Is light	Lat 42 20 36 Long 70 58 45	1	Flood	19.5	8	5.40	100
1208	10.06	" "	Lat 42 20 36 Long 70 58 45	10	Flood	19	6	5.40	100
1209	10.08	" "	Lat 42 20 36 Long 70 58 45	20	Flood	19	6	5.40	100

Sample No	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
1210	10.18	1000 feet west of Deer Is light	Lat 42 20 22 Long 70 57 30	1	Flood	19.5	12	5.07	94
1211	10.19	1000 feet west of Deer Is light	Lat 42 20 22 Long 70 57 30	20	Flood	19	6	5.52	100
1212	10.21	1000 feet west of Deer Is light	Lat 42 20 22 Long 70 57 30	45	Flood	19	6	5.52	100
1213	10.40	10 feet west of Sewer outlet at Deer Is light	Lat 42 20 23 Long 70 57 18	1	Flood	19.5	32	2.99	53
1214	10.42	10 feet west of Sewer outlet at Deer Is light	Lat 42 20 23 Long 70 57 18	7	Flood	19	11	4.78	88

Dissolved Oxygen — Boston inner harbor and Charles River — August 29, 1911

High water at Boston at 5.17 p. m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1215	1.20	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	1	Flood	19.5	52	2.27	38
1216	1.21	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	15	Flood	19	12	3.41	62
1217	1.25	Charles river midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	30	Flood	19	10	3.42	62
1218	1.38	Midway between East Boston docks and entrance to South bay	Lat 42 21 39 Long 71 02 35	1	Flood	19.5	10	4.38	81
1219	1.35	Midway between East Boston docks and entrance to South bay	Lat 42 21 39 Long 71 02 35	15	Flood	19	6	4.79	89
1220	1.35	Midway between East Boston docks and entrance to South bay	Lat 42 21 39 Long 71 02 35	30	Flood	19	6	4.79	89
1221	1.44	By buoy 10 between Governors Is and East Boston docks	Lat 42 21 35 Long 71 01 10	1	Flood	19.5	10	4.69	87
1222	1.45	By buoy 10 between Governors Is and East Boston docks	Lat 42 21 35 Long 71 01 10	10	Flood	19	6	5.11	95
1223	1.47	By buoy 10 between Governors Is and East Boston docks	Lat 42 21 35 Long 71 01 10	15	Flood	19	6	5.11	95
1224	1.57	Midway between Governors Is and Castle Is	Lat 42 20 42 Long 71 00 42	1	Flood	19.5	8	5.22	97
1225	1.58	Midway between Governors Is and Castle Is	Lat 42 20 42 Long 71 00 42	15	Flood	19	6	5.80	100
1226	2.00	Midway between Governors Is and Castle Is	Lat 42 20 42 Long 71 00 42	30	Flood	19	6	5.80	100
1227	2.20	Midway between Governors Is and Deer Is light	Lat 42 20 36 Long 70 58 45	1	Flood	19	6	5.40	100
1228	2.21	Midway between Governors Is and Deer Is light	Lat 42 20 36 Long 70 58 45	10	Flood	19	6	5.40	100
1229	2.23	Midway between Governors Is and Deer Is light	Lat 42 20 36 Long 70 58 45	20	Flood	19	6	5.40	100

Dissolved Oxygen — Boston outer harbor in the vicinity of Deer Island light — August 29, 1911

High water at Boston at 8.17 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1230	2.30	500 feet east of Deer Is light	Lat 42 20 26 Long 70 57 12	1	Flood	19	11	4.98	91
1231	2.31	500 feet east of Deer Is light	Lat 42 20 26 Long 70 57 12	15	Flood	19	8	5.50	100
1232	2.33	500 feet east of Deer Is light	Lat 42 20 26 Long 70 57 12	30	Flood	19	7	5.50	100
1233	3.45	250 feet east of Deer Is light	Lat 42 26 26 Long 70 57 14	Surface	Ebb	19.5	12	4.93	91
1234	3.46	250 feet east of Deer Is light	Lat 42 26 26 Long 70 57 14	1	Ebb	19.5	12	4.93	91
1235	3.48	250 feet east of Deer Is light	Lat 42 26 26 Long 70 57 14	2	Ebb	19	10	5.11	95
1236	3.50	250 feet east of Deer Is light	Lat 42 26 26 Long 70 57 14	3	Ebb	19	8	5.40	100
1237	3.52	250'east of Deer Is light	Lat 42 26 26 Long 70 57 14	5	Ebb	19	6	5.47	100
1238	3.54	250'east of Deer Is light	Lat 42 26 26 Long 70 57 14	10	Ebb	19	6	5.47	100
1239	3.56	250'east of Deer Is light	Lat 42 26 26 Long 70 57 14	15	Ebb	19	6	5.52	100
1240	3.58	250'east of Deer Is light	Lat 42 26 26 Long 70 57 14	30	Ebb	19	6	5.52	100

Dissolved Oxygen — Boston outer harbor in the vicinity of Deer Island light — August 30, 1911

High water at Boston at 4.06 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1241	11.00	100 feet southwest of Deer Is light	Lat 42 20 25 Long 70 57 18	Surface	Flood	19.8	12	4.82	90
1242	11.01	100 feet southwest of Deer Is light	Lat 42 20 25 Long 70 57 18	1	Flood	19.8	12	4.82	90
1243	11.02	100 feet southwest of Deer Is light	Lat 42 20 25 Long 70 57 18	2	Flood	19	8	5.28	98
1244	11.06	100 feet southwest of Deer Is light	Lat 42 20 25 Long 70 57 18	5	Flood	19	6	5.42	100
1245	11.07	100 feet southwest of Deer Is light	Lat 42 20 23 Long 70 57 18	8	Flood	19	6	5.47	100
1246	11.09	100 feet southwest of Deer Is light	Lat 42 20 23 Long 70 57 18	10	Flood	19	6	5.47	100
1247	11.11	100 feet southwest of Deer Is light	Lat 42 20 23 Long 70 57 18	20	Flood	19	6	5.52	100
1248	11.15 p.m.	100 feet southwest of Deer Is light	Lat 42 20 23 Long 70 57 18	60	Flood	19	6	5.52	100
1249	3.46	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	Surface	Flood	19.8	20	4.97	80
1250	3.48	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	1	Flood	19.8	20	4.97	80
1251	3.50	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	2	Flood	19	12	5.14	98
1252	3.52	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	3	Flood	19	6	5.42	100
1253	3.54	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	5	Flood	19	6	5.40	100
1254	3.56	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	10	Flood	19	6	5.40	100
1255	3.58	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	20	Flood	19	6	5.52	100
1256	4.00	100 feet south of Deer Is light	Lat 42 20 22 Long 70 57 17	60	Flood	19	6	5.52	100

Dissolved Oxygen — Boston outer harbor off Peddocks Island

High water at Boston 9.08 a.m. — September 8, 1911

Sample No	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1257	1.30	About 1/4 mile north of west extremity of Peddock's Is.	Lat 42 17 39 Long 70 59 04	Surface	Ebb	19	16	4.98	86
1258	1.32	" "	Lat 42 17 39 Long 70 59 04	1	Ebb	19	16	4.98	86
1259	1.34	" "	Lat 42 17 39 Long 70 59 04	2	Ebb	19	14	5.11	90
1260	1.36	" "	Lat 42 17 39 Long 70 59 04	5	Ebb	19	10	5.37	96
1261	1.38	" "	Lat 42 17 39 Long 70 59 04	8	Ebb	19	8	5.37	98
1262	1.40	" "	Lat 42 17 39 Long 70 59 04	10	Ebb	19	6	5.47	99
1263	1.42	" "	Lat 42 17 39 Long 70 59 04	15	Ebb	19	6	5.66	100
1264	1.44	" "	Lat 42 17 39 Long 70 59 04	30	Ebb	19	6	5.66	100
1265	2.30	Just south of Sunken Ledge Beacon off Peddock's Is	Lat 42 17 32 Long 70 59 39	Surface	Ebb	19	8	5.52	100
1266	2.32	" "	Lat 42 17 32 Long 70 59 39	1	Ebb	19	8	5.50	100
1267	2.34	" "	Lat 42 17 32 Long 70 59 39	2	Ebb	19	8	5.54	100
1268	2.36	" "	Lat 42 17 32 Long 70 59 39	3	Ebb	19	8	5.54	100
1269	2.38	" "	Lat 42 17 32 Long 70 59 39	5	Ebb	19	8	5.54	100
1270	2.40	" "	Lat 42 17 32 Long 70 59 39	10	Ebb	19	8	5.56	100
1271	2.42	" "	Lat 42 17 32 Long 70 59 39	15	Ebb	19	8	5.56	100

Dissolved Oxygen. Boston outer harbor off Moon Head September 6, 1911

High water at Boston 9.50 a.m.

Sample No	Hour a.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1272	11.00	1000 feet north of Moon Head sewer outlet	Lat 42	18	38	Surface	Ebb	18.5	18	4.26	73
			Long 70	59	30						
1273	11.02	" "	Lat 42	18	38	1	Ebb	18.5	18	4.35	75
			Long 70	59	30						
1274	11.04	" "	Lat 42	18	38	2	Ebb	18.5	14	5.11	90
			Long 70	59	30						
1275	11.06	" "	Lat 42	18	38	3	Ebb	18.5	12	5.33	95
			Long 70	59	30						
1276	11.08	" "	Lat 42	18	38	5	Ebb	18.5	10	5.47	98
			Long 70	59	30						
1277	11.10	" "	Lat 42	18	38	10	Ebb	18.5	8	5.54	99
			Long 70	59	30						
1278	11.12	" "	Lat 42	18	38	15	Ebb	18.5	6	5.65	100
			Long 70	59	30						
1279	12.10	Near red buoy 36 north of Spectacle Is. Buoy about 3/4 mile north of Moon Head outlet	Lat 42	19	06	Surface	Ebb	18.5	8	5.60	100
			Long 70	59	15						
1280	12.12	" "	Lat 42	19	06	1	Ebb	18.5	8	5.62	100
			Long 70	59	15						
1281	12.14	" "	Lat 42	19	06	2	Ebb	18.5	6	5.65	100
			Long 70	59	15						
1282	12.16	" "	Lat 42	19	06	3	Ebb	18.5	6	5.65	100
			Long 70	59	15						
1283	12.18	" "	Lat 42	19	06	5	Ebb	18.5	6	5.68	100
			Long 70	59	15						
1284	12.20	" "	Lat 42	19	06	10	Ebb	18.5	6	5.68	100
			Long 70	59	15						
1285	12.22	" "	Lat 42	19	06	20	Ebb	18.5	6	5.68	100
			Long 70	59	15						

Dissolved Oxygen. Boston outer harbor off Peddocks Island.

September 7, 1911.

High water at Boston at 10.28 a.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact o ' "						
1286	10.36	About 1/4 mile north of western extremity of Peddocks Island.	Lat 42 17 39 Long 70 57 04	Surface	Ebb	17	16	4.83	83
1287	10.38	" "	Lat 42 17 39 Long 70 57 04	1	Ebb	17	16	4.93	85
1288	10.40	" "	Lat 42 17 39 Long 70 57 04	2	Ebb	17	14	5.07	88
1289	10.42	" "	Lat 42 17 39 Long 70 57 04	5	Ebb	17	8	5.56	98
1290	10.44	" "	Lat 42 17 39 Long 70 57 04	5	Ebb	17	8	5.56	96
1291	10.46	" "	Lat 42 17 39 Long 70 57 04	10	Ebb	17	6	5.65	100
1292	10.48	" "	Lat 42 17 39 Long 70 57 04	15	Ebb	17	4	5.68	100
1293	10.50	" "	Lat 42 17 39 Long 70 57 04	35	Ebb	17	4	5.68	100

Dissolved Oxygen. Boston outer harbor off Moon Head. September 7, 1911.

High water at Boston at 10.28 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact				Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
1294	11.20	500 feet north of sewer outlet at northwest corner of Moon Head.	Lat	42	18	33	1	Ebb	17	8	5.68	100
			Long	70	59	29						
1295	11.22	500 feet north of sewer outlet at northwest corner of Moon Head	Lat	42	18	33	20	Ebb	17	4	5.68	100
			Long	70	59	29						
1296	12.18	" "	Lat	42	18	33	Surface	Ebb	17	20	3.98	68
			Long	70	59	29						
1297	12.20	" "	Lat	42	18	33	1	Ebb	17	20	3.98	68
			Long	70	59	29						
1298	12.22	" "	Lat	42	18	33	2	Ebb	17	14	4.49	78
			Long	70	59	29						
1299	12.24	" "	Lat	42	18	33	3	Ebb	17	12	5.00	88
			Long	70	59	29						
1300	12.26	" "	Lat	42	18	33	5	Ebb	17	12	5.37	94
			Long	70	59	29						
1301	12.28	" "	Lat	42	18	33	10	Ebb	17	10	5.52	97
			Long	70	59	29						
1302	12.30	" "	Lat	42	18	33	20	Ebb	17	8	5.68	100
			Long	70	59	29						

Dissolved Oxygen. Charles River at Boston. September 8, 1911.

High water at Boston at 11.08 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1303	10.00	Charles river, midway between mouth and lowest drawbridge	Lat 42 22 15 Long 71 03 18	Surface	Flood	17	28	2.56	43
1304	10.02	Charles river, midway between mouth and lowest drawbridge	Lat 42 22 15 Long 71 03 18	20	Flood	17	16	3.69	64

Ex. 94. p.112

Dissolved Oxygen. Boston outer harbor off Peddocke Island.

September 9, 1911.

High water at Boston at 11.45 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact:	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Percent saturation
1305	10.20	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	Surface	Flood	17	8	5.67	100
			Long	70	57	04						
1306	10.22	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	1	Flood	17	8	5.67	100
			Long	70	57	04						
1307	10.24	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	2	Flood	17	8	5.67	100
			Long	70	57	04						
1308	10.26	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	3	Flood	17	8	5.68	100
			Long	70	57	04						
1309	10.28	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	5	Flood	17	6	5.68	100
			Long	70	57	04						
1310	10.30	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	10	Flood	17	6	5.68	100
			Long	70	57	04						
1311	10.32	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	15	Flood	17	6	5.70	100
			Long	70	57	04						
1312	10.34	About 1/4 mile north of west extremity of Peddocke Island	Lat	42	17	39	36	Flood	17	6	5.70	100
			Long	70	57	04						

Ex. 94. p.114

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3560

Dissolved Oxygen. Boston outer harbor off Peddocks Island.

September 11, 1911.

High water at Boston at 1.06 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percentage-tion
1513	10.00	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	Surface	Flood	17	14	4.69	68
1514	10.02	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	1	Flood	17	14	4.88	82
1515	10.04	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	2	Flood	17	14	4.98	86
1516	10.06	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	3	Flood	17	12	5.22	98
1517	10.08	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	5	Flood	17	12	5.27	94
1518	10.10	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	10	Flood	17	10	5.40	98
1519	10.12	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	15	Flood	17	10	5.34	98
1520	10.14	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 14	20	Flood	17	8	4.70	100

REPORT OF STATE OF NEW YORK, STATE OF NEW JERSEY, 1911.

Dissolved Oxygen. Boston outer harbor off Moon Head. September 11, 1911.

High water at Boston at 2.0^{m} p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.F	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent ature-tion
1321	8.00	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	Surface	Ebb	17	22	8.96	68
1322	8.02	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	1	Ebb	17	22	8.96	68
1323	8.04	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	2	Ebb	17	18	4.48	76
1324	8.06	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	5	Ebb	17	14	8.07	97
1325	8.08	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	6	Ebb	17	12	8.08	98
1326	8.10	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	10	Ebb	17	8	8.82	97
1327	8.12	1000 feet north of Moon Head outlet	Lat 42 19 30 Long 70 89 30	15	Ebb	17	6	8.69	100
1328	8.80	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	Surface	Ebb	17	20	4.84	72
1329	8.82	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	1	Ebb	17	20	4.84	72
1330	8.84	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	2	Ebb	17	16	4.92	88
1331	8.86	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	5	Ebb	17	12	8.88	98
1332	8.88	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	8	Ebb	17	10	8.81	97
1333	8.40	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	10	Ebb	17	6	8.68	100
1334	8.42	By red buoy 3 S., south of Long Island, west end.	Lat 42 19 30 Long 70 88 27	20	Ebb	17	6	8.70	100

Dissolved Oxygen. Boston outer Harbor off Moon Head. Sept. 11, 1911.
1000' east of red buoy S 2, south of
High water occurred at Boston at 1.06 p.m. Long Island.

Sample No.	Hour p.m.	Location of Samples				Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate				Exact o ' "	Feet below surface			C.C. per litre	Percent saturation
1335	4.00	1000' east of red buoy S 2, south of Long Island				Lat 42 18 32 Long 70 58 14	surface	Ebb	17	8	5.54	97
1336	4.02	"	"	"	"	Lat 42 18 32 Long 70 58 14	1	Ebb	17	8	5.54	97
1337	4.04	"	"	"	"	Lat 42 18 32 Long 70 58 14	2	Ebb	17	8	5.54	97
1338	4.06	"	"	"	"	Lat 42 18 32 Long 70 58 14	5	Ebb	17	6	5.60	98
1339	4.08	"	"	"	"	Lat 42 18 32 Long 70 58 14	5	Ebb	17	6	5.56	97
1340	4.10	"	"	"	"	Lat 42 18 32 Long 70 58 14	10	Ebb	17	6	5.46	96
1341	4.12	"	"	"	"	Lat 42 18 32 Long 70 58 14	25	Ebb	17	6	5.46	96

Dissolved Oxygen. Boston outer harbor, off Peddock's Island, about ¼ mile north of west end of Peddock's Is. Over outlet, which discharges 30' below surface. Sept. 12, 1911

High water occurred at Boston 1.50 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1342	9.40 a.m.	About ¼ mile north of west end of Peddocks Is. over outlet, which discharges 30' below surface	Lat 42 17 39 Long 70 57 04	surface	Flood	17	12	5.19	89
1343	9.42	" " " "	Lat 42 17 39 Long 70 57 04	1	Flood	17	12	5.18	89
1344	9.44	" " " "	Lat 42 17 39 Long 70 57 04	2	Flood	17	12	5.22	90
1345	9.46	" " " "	Lat 42 17 39 Long 70 57 04	3	Flood	17	10	5.37	94
1346	9.48	" " " "	Lat 42 17 39 Long 70 57 04	5	Flood	17	10	5.40	95
1347	9.50	" " " "	Lat 42 17 39 Long 70 57 04	10	Flood	17	8	5.52	97
1348	9.52	" " " "	Lat 42 17 39 Long 70 57 04	15	Flood	17	8	5.56	98
1349	9.54	" " " "	Lat 42 17 39 Long 40 57 04	35	Flood	17	6	5.74	100
1350	10.50	Near sunken ledge beacon ¼mile west of Peddock's Is. outlet	Lat 42 17 32 Long 70 57 37	surface	Flood	17	8	5.68	100
1351	10.52	" " " "	Lat 42 17 32 Long 70 57 37	1	Flood	17	8	5.68	100
1352	10.54	" " " "	Lat 42 17 32 Long 70 57 37	2	Flood	17	8	5.68	100
1353	10.56	" " " "	Lat 42 17 32 Long 70 57 37	3	Flood	17	6	5.70	100
1354	10.58	" " " "	Lat 42 17 32 Long 70 57 37	5	Flood	17	6	5.73	100
1355	11.00	" " " "	Lat 42 17 32 Long 70 57 37	10	Flood	17	6	5.74	100

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3561

Dissolved Oxygen.

Boston outer harbor off Peddocks Island.

(continued)

Sept. 12, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1357	11.02	near Sunken Ledge beacon ½mile west of Peddocks Is. outlet	Lat 42 17 32 Long 70 57 37	15	Flood	17	6	5.74	100
1357	11.50	¼ mile east of Peddocks Is. outlet	Lat 42 17 44 Long 70 56 30	surface	Flood	17	8	5.68	100
1358	11.52	" " "	Lat 42 17 44 Long 70 56 30	1	Flood	17	8	5.68	100
1359	11.54	" " "	Lat 42 17 44 Long 70 56 30	2	Flood	17	8	5.68	100
1360	11.56	" " "	Lat 42 17 44 Long 70 56 30	3	Flood	17	6	5.70	100
1361	11.58	" " "	Lat 42 17 44 Long 70 56 30	5	Flood	17	6	5.74	100
1362	12.00	" " "	Lat 42 17 44 Long 70 56 30	10	Flood	17	6	5.74	100
1363	12.02	" " "	Lat 42 17 44 Long 70 56 30	15	Flood	17	6	5.74	100
1364	2.00 p.m.	About ¼ mile north of west end of Peddocks Is. over outlet, discharging 30' below surface	Lat 42 17 39 Long 70 57 04	surface	Ebb	17	14	4.92	85
1365	2.02	" " "	Lat 42 17 39 Long 70 57 04	1	Ebb	17	14	4.92	85
1366	2.04	" " "	Lat 42 17 39 Long 70 57 04	2	Ebb	17	14	4.93	86
1367	2.06	" " "	Lat 42 17 39 Long 70 57 04	3	Ebb	17	12	5.07	89
1368	2.08	" " "	Lat 42 17 39 Long 70 57 04	5	Ebb	17	10	5.22	92
1369	2.10	" " "	Lat 42 17 39 Long 70 57 04	10	Ebb	17	8	5.28	93
1370	2.12	" " "	Lat 42 17 39 Long 70 57 04	15	Ebb	17	6	5.42	95
1371	2.14	" " "	Lat 42 17 39 Long 70 57 04	35	Ebb	17		5.65	99

Dissolved Oxygen. Charles River, Boston. September 13, 1911.

High water at Boston at 2.37 p.m.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "	Feet below surface				C.C. per litre	Percent satura-tion
1372	9.30	Charles river, midway between mouth and lowest bridge	Lat 42 22 15 Long 71 03 18	1	Flood	15	26	3.77	64
1373	9.34	" " " "	Lat 42 22 15 Long 71 03 18	20	Flood	16.8	12	3.77	66

Ex. 94. p.180

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1916.

Dissolved Oxygen. Boston outer harbor off Peddocks Island.

September 14, 1911.

High water at Boston at 3.29 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1374	10.15	About 1/4 mile north of west end of Peddocks Island	Lat 42 17 39 Long 70 57 04	Surface	Flood	15.5	14	5.19	88
1375	10.16	" " " " "	Lat 42 17 39 Long 70 57 04	1	Flood	15.5	14	5.19	88
1376	10.18	" " " " "	Lat 42 17 39 Long 70 57 04	2	Flood	15.5	14	5.22	89
1377	10.20	" " " " "	Lat 42 17 39 Long 70 57 04	3	Flood	15.5	12	5.37	93
1378	10.22	" " " " "	Lat 42 17 39 Long 70 57 04	5	Flood	15.5	12	5.40	96
1379	10.24	" " " " "	Lat 42 17 39 Long 70 57 04	10	Flood	15.5	10	5.52	97
1380	10.26	" " " " "	Lat 42 17 39 Long 70 57 04	15	Flood	15.5	10	5.56	98
1381	10.28	" " " " "	Lat 42 17 39 Long 70 57 04	35	Flood	15.5	8	5.74	94
1382	11.00	Half-way between outlet and west end of Peddocks Island	Lat 42 17 32 Long 70 57 02	Surface	Flood	15.5	12	5.46	94
1383	11.02	" " " " "	Lat 42 17 32 Long 70 57 02	1	Flood	15.5	12	5.46	94
1384	11.04	" " " " "	Lat 42 17 32 Long 70 57 02	2	Flood	15.5	12	5.46	94
1385	11.06	" " " " "	Lat 42 17 32 Long 70 57 02	3	Flood	15.5	10	5.56	96
1386	11.08	" " " " "	Lat 42 17 32 Long 70 57 02	5	Flood	15.5	10	5.56	96
1387	11.10	" " " " "	Lat 42 17 32 Long 70 57 02	10	Flood	15.5	8	5.68	98

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 25417

Dissolved Oxygen. Boston outer harbor off Peddocks Island.

(Continued.) September 14, 1911.

Sample No.	Hour a.m.	Location of Sample: Approximate	Location of Sample: Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
1388	11.18	Half-way between outlet and west end of Peddocks Island	Lat 42 17 32 Long 70 57 08	18	Flood	18.8	6	5.80	100
1389	11.14	" " " " "	Lat 42 17 32 Long 70 57 08	38	Flood	18.5	5	5.80	100
1390	11.50	About 1/4 mile west of west end of Peddocks Island	Lat 42 17 23 Long 70 57 18	Surface	Flood	18.8	8	5.60	97
1391	11.58	" " " "	Lat 42 17 22 Long 70 57 18	1	Flood	18.8	8	5.60	97
1392	11.54	" " " "	Lat 42 17 23 Long 70 57 18	2	Flood	18.8	8	5.60	97
1393	11.56	" " " "	Lat 42 17 23 Long 70 57 18	3	Flood	18.8	6	5.68	98
1394	11.58	" " " "	Lat 42 17 23 Long 70 57 18	8	Flood	18.8	6	5.68	98
1395	12.00	" " " "	Lat 42 17 23 Long 70 57 18	10	Flood	18.8	6	5.68	98
1396	12.02	" " " "	Lat 42 17 23 Long 70 57 18	18	Flood	18.8	6	5.56	96
1397	12.04	" " " "	Lat 42 17 23 Long 70 57 18	28	Flood	18.8	6	5.56	96
1398	1.00	1/2 mile S. W. of outlet	Lat 42 17 16 Long 70 57 22	Surface	Flood	18.8	8	5.60	97
1399	1.01	" " " " " "	Lat 42 17 16 Long 70 57 22	1	Flood	18.8	8	5.60	97
1400	1.03	" " " " " "	Lat 42 17 16 Long 70 57 22	2	Flood	18.8	8	5.60	97
1401	1.06	" " " " " "	Lat 42 17 14 Long 70 57 22	3	Flood	18.8	6	5.68	98

Dissolved Oxygen. Boston outer harbor off Peddocks Island.

(Continued.) September 14, 1911.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent ature-tion
		Approximate	Exact ° ' "	Feet below surface					
1402	1.07	1/2 mile S. W. of outlet	Lat 42 17 16 Long 70 57 22	8	Flood	18.5	6	8.68	98
1403	1.09	" " " " "	Lat 42 17 16 Long 70 57 22	10	Flood	18.5	6	8.68	98
1404	1.11	" " " " "	Lat 42 17 16 Long 70 57 22	18	Flood	18.5	6	8.86	98
1405	1.13	" " " " "	Lat 42 17 16 Long 70 57 22	30	Flood	18.5	6	8.82	98
1406	2.00	By black buoy S 3 between Long Is. and Hainsford Is.	Lat 42 19 04 Long 70 56 58	1	Flood	18.5	6	8.74	100
1407	2.02	" " " " "	Lat 42 19 04 Long 70 56 58	18	Flood	18.5	4	8.74	100
1408	2.04	" " " " "	Lat 42 19 04 Long 70 56 58	30	Flood	18.5	4	8.74	100
1409	2.30	Cove north of middle of Peddocks Is. 1000' off shore	Lat 42 17 46 Long 70 56 22	1	Flood	18.5	6	8.51	97
1410	2.32	" " " " "	Lat 42 17 46 Long 70 56 22	10	Flood	18.5	4	8.51	97
1411	2.34	" " " " "	Lat 42 17 46 Long 70 56 22	18	Flood	18.5	4	8.51	97
1412	4.00	About 1/4 mile N. of west end of Peddocks Island	Lat 42 19 39 Long 70 57 04	1	Flood	15.5	14	4.93	63
1413	4.04	" " " "	Lat 42 19 39 Long 70 57 04	30	Flood	15.5	6	8.60	100

Dissolved Oxygen. Boston outer harbor off Moon Island.

September 14, 1911.

High water at Boston at 3.29 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent satura-tion
1414	5.00	Midway between Moon Head outlet and East end of Spectacle Is.	Lat 42 18 52 Long 70 59 17	Surface	Ebb	15.5	18	3.98	68
1415	5.02	" " " " "	Lat 42 18 52 Long 70 59 17	1	Ebb	15.5	18	3.98	68
1416	5.04	" " " " "	Lat 42 18 52 Long 70 59 17	2	Ebb	15.5	14	4.11	73
1417	5.06	" " " " "	Lat 42 18 52 Long 70 59 17	3	Ebb	15.5	12	4.90	86
1418	5.08	" " " " "	Lat 42 18 52 Long 70 59 17	5	Ebb	15.5	10	5.22	92
1419	5.10	" " " " "	Lat 42 18 52 Long 70 59 17	10	Ebb	15.5	6	5.52	97
1420	5.12	" " " " "	Lat 42 18 52 Long 70 59 17	15	Ebb	15.5	4	5.68	100
1421	5.30	By buoy S 4 off west end of Long Island	Lat 42 18 34 Long 70 58 46	Surface	Ebb	15.5	16	4.26	72
1422	5.32	" " " " " " "	Lat 42 18 34 Long 70 58 46	1	Ebb	15.5	16	4.26	72
1423	5.34	" " " " " " "	Lat 42 18 34 Long 70 58 46	2	Ebb	15.5	14	4.64	80
1424	5.36	" " " " " " "	Lat 42 18 34 Long 70 58 46	3	Ebb	15.5	12	5.00	86
1425	5.38	" " " " " " "	Lat 42 18 34 Long 70 58 46	5	Ebb	15.5	10	5.51	97
1426	5.40	" " " " " " "	Lat 42 18 34 Long 70 58 46	10	Ebb	15.5	6	5.68	100
1427	5.42	" " " " " " "	Lat 42 18 34 Long 70 58 46	15	Ebb	15.5	4	5.68	100

Dissolved Oxygen. Boston outer harbor off Moon Head. Sept. 14, 1911.

Sample No.	Hour p.m.	Location of Samples									Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate					Exact			Feet below surface				C.C. per litre	Percent saturation
1428	6.04	By buoy S 2, south of west end of Long Island					Lat	42 18 30		Surface	Ebb	15.5	8	5.54	96
							Long	70 58 27							
1429	6.06	"	"	"	"	"	Lat	42 18 30		1	Ebb	15.5	8	5.54	96
							Long	70 58 27							
1430	6.08	"	"	"	"	"	Lat	42 18 30		2	Ebb	15.5	6	5.54	96
							Long	70 58 27							
1431	6.10	"	"	"	"	"	Lat	42 18 30		3	Ebb	15.5	6	5.60	98
							Long	70 58 27							
1432	6.12	"	"	"	"	"	Lat	42 18 30		5	Ebb	15.5	6	5.56	97
							Long	70 58 27							
1433	6.14	"	"	"	"	"	Lat	42 18 30		10	Ebb	15.5	4	5.46	96
							Long	70 58 27							
1434	6.16	"	"	"	"	"	Lat	42 18 30		20	Ebb	15.5	4	5.46	96
							Long	70 58 27							

Ex. 94. p.125

Dissolved Oxygen. Boston outer harbor off Peddocke Island.

September 15, 1911.

High water at Boston at 4.26 p.m.

Sample No.	Hour a.m.	Location of Samples		Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact	Feet below surface			C.C. per litre	Percent saturation
1435	10.30	About 1/4 mile north of west end of Peddocke Island, over outlet	Lat 42 17 39 Long 70 57 04	Surface	Flood	15.5	14	5.19	88
1436	10.32	" " " " " "	Lat 42 17 39 Long 70 57 04	1	Flood	15.5	14	5.19	88
1437	10.34	" " " " " "	Lat 42 17 39 Long 70 57 04	2	Flood	15.5	14	5.22	89
1438	10.36	" " " " " "	Lat 42 17 39 Long 70 57 04	3	Flood	15.5	12	5.37	93
1439	10.38	" " " " " "	Lat 42 17 39 Long 70 57 04	5	Flood	15.5	10	5.54	96
1440	10.40	" " " " " "	Lat 42 17 39 Long 70 57 04	10	Flood	15.5	10	5.52	96
1441	10.42	" " " " " "	Lat 42 17 39 Long 70 57 04	15	Flood	15.5	8	5.56	97
1442	10.44	" " " " " "	Lat 42 17 39 Long 70 57 04	20	Flood	15.5	6	5.74	99

Dissolved Oxygen. Boston outer harbor off Moon Head. Sept. 18, 1911.

High water at Boston at 4.26 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1443	11.30	1000 feet outlet north of Moon Head	Lat 42 18 38 Long 70 59 30	Surface	Flood	15.5	6	5.68	100
1444	11.32	" " " " " "	Lat 42 18 38 Long 70 59 30	1	Flood	15.5	6	5.68	100
1445	11.34	" " " " " "	Lat 42 18 38 Long 70 59 30	2	Flood	15.5	6	5.68	100
1446	11.36	" " " " " "	Lat 42 18 38 Long 70 59 30	3	Flood	15.5	6	5.70	100
1447	11.38	" " " " " "	Lat 42 18 38 Long 70 59 30	5	Flood	15.5	4	5.70	100
1448	11.40	" " " " " "	Lat 42 18 38 Long 70 59 30	10	Flood	15.5	4	5.74	100
1449	11.42	" " " " " "	Lat 42 18 38 Long 70 59 30	15	Flood	15.5	4	5.74	100

Ex. 94. p.127

Dissolved Oxygen. Boston Outer Harbor, off Moon Head, about 1 mile S.E. of Moon Head outlet and 1 mile S of west end of Long Island.

High water occurred at Boston at 7.17 a.m.

Sample No.	Hour a.m.	Location of Samples		Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "	Feet below surface			C.C. per litre	Percent saturation
1450	9.15	About 1 mile S.E. of Moon Head outlet and 1 mile S of west end of Long Is.	Lat 42 18 02 Long 70 58 27	surface	Ebb	15.5	6	5.07	88
1451	9.17	" " "	Lat 42 18 02 Long 70 58 27	1	Ebb	15.5	6	5.07	88
1452	9.19	" " "	Lat 42 18 02 Long 70 58 27	2	Ebb	15.5	6	5.11	89
1453	9.21	" " "	Lat 42 18 02 Long 70 58 27	3	Ebb	15.5	6	5.11	89
1454	9.23	" " "	Lat 42 18 02 Long 70 58 27	5	Ebb	15.5	6	5.11	89
1455	9.25	" " "	Lat 42 18 02 Long 70 58 27	10	Ebb	15.5	6	5.00	86
1456	9.27	" " "	Lat 42 18 02 Long 70 58 27	15	Ebb	15.5	6	5.00	86
1457	9.30	" " "	Lat 42 18 02 Long 70 58 27	surface	Ebb	15.5	14	4.40	75
1458	9.32	" " "	Lat 42 18 02 Long 70 58 27	1	Ebb	15.5	14	4.40	75
1459	9.34	" " "	Lat 42 18 02 Long 70 58 27	2	Ebb	15.5	12	4.78	82
1460	9.36	" " "	Lat 42 18 02 Long 70 58 27	3	Ebb	15.5	10	5.14	89
1461	9.38	" " "	Lat 42 18 02 Long 70 58 27	5	Ebb	15.5	10	5.81	97
1462	10.00	" " "	Lat 42 18 02 Long 70 58 27	10	Ebb	15.5	6	5.68	100
1463	10.02	" " "	Lat 42 18 02 Long 70 58 27	15	Ebb	15.5	6	5.70	100

Dissolved Oxygen. Boston outer Harbor off Moon Head (continued)

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1464	10.25	1000' North of Moon Head outlet	Lat 42 18 30 Long 70 89 30	surface	Ebb	18.8	18	5.90	88
1465	10.27	" " " "	Lat 42 18 30 Long 70 89 30	1	Ebb	18.8	18	5.90	88
1466	10.29	" " " "	Lat 42 18 30 Long 70 89 30	5	Ebb	18.8	14	4.86	74
1467	10.31	" " " "	Lat 42 18 30 Long 70 89 30	5	Ebb	18.8	12	4.90	86
1468	10.38	" " " "	Lat 42 18 30 Long 70 89 30	5	Ebb	18.8	10	5.88	87
1469	10.38	" " " "	Lat 42 18 30 Long 70 89 30	10	Ebb	18.8	8	5.82	87
1470	10.37	" " " "	Lat 42 18 30 Long 70 89 30	15	Ebb	18.8	8	5.80	86
1471	11.00	About ¼ mile S of location of samples #1459-63, which were taken near S. edge of discolored field	Lat 42 17 30 Long 70 88 28	surface	Ebb	18.8	6	5.80	90
1472	11.02	" " "	Lat 42 17 30 Long 70 88 28	10	Ebb	18.8	6	5.80	90
1473	11.04	" " "	Lat 42 17 30 Long 70 88 28	15	Ebb	18.8	6	5.82	87

Dissolved Oxygen. Narrows-Cross-section between Ports Lafayette and Wadsworth. Sept. 26, 1911.

Low water occurred at Governors Island at 6.17 a.m. High water at 10.30 a.m. Low water at 4.37 p.m.

Flood currents began about 7 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1474	6.30	800 feet off Port Lafayette	Lat	40 36 29		1	Slack	20.	30	3.69	65
			Long	74 02 24							
1475	6.32	800 feet off Port Lafayette	Lat	40 36 29		20	Slack	20.	24	3.68	64
			Long	74 02 24							
1476	6.34	800 feet off Port Lafayette	Lat	40 36 29		40	Slack	20.	24	3.68	64
			Long	74 02 24							
1477	6.39	1/4 way across from Port Lafayette	Lat	40 36 27		1	Slack	20.	30	3.79	67
			Long	74 02 24							
1478	6.41	1/4 way across from Port Lafayette	Lat	40 36 27		40	Slack	20.	24	3.92	70
			Long	74 02 24							
1479	6.43	1/4 way across from Port Lafayette	Lat	40 36 27		80	Slack	20.	24	3.92	70
			Long	74 02 24							
1480	6.48	Half way across	Lat	40 36 25			Slack	20.	30	3.91	69
			Long	74 02 46		1					
1481	6.50	Half way across	Lat	40 36 25		40	Slack	20.	24	3.91	70
			Long	74 02 46							
1482	6.52	Half way across	Lat	40 36 25		80	Slack	20.	24	3.91	70
			Long	74 02 46							
1483	6.57	3/4 way across from Port Lafayette	Lat	40 36 23		1	Slack	20.	30	3.84	68
			Long	74 03 02							
1484	6.59	3/4 way across from Port Lafayette	Lat	40 36 23		40	Slack	20.	24	3.84	69
			Long	74 03 02							
1485	7.01	3/4 way across from Port Lafayette	Lat	40 36 23		80	Slack	20.	24	3.84	69
			Long	74 03 02							
1486	7.06	800 feet off Port Wadsworth	Lat	40 36 21		1	Flood	20.	30	3.75	66
			Long	74 03 12							
1487	7.08	800 feet off Port Wadsworth	Lat	40 36 21		30	Flood	20.	24	3.89	69
			Long	74 03 12							
1488	7.10	800 feet off Port Wadsworth	Lat	40 36 21		60	Flood	20.	24	3.89	69
			Long	74 03 12							

Dissolved Oxygen. The Narrows-Cross-section between Forts Lafayette and Wadsworth. Sept. 26, 1911.

Low water occurred at Governors Island at 4.17 a.m. High water at 10.33 a.m. Low water at 4.57 p.m.

Flood currents began about 7 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	C.C. per litre	Percent saturation
1489	8.30	200 feet off Fort Lafayette	Lat	40 36 29		1	Flood	20	26	4.65	83
			Long	74 02 24							
1490	8.32	" " " " "	Lat	40 36 29		20	Flood	20	20	4.94	89
			Long	74 02 24							
1491	8.34	" " " " "	Lat	40 36 29		40	Flood	20	20	4.94	89
			Long	74 02 24							
1492	8.39	1/4 way across from Fort Lafayette	Lat	40 36 27		1	Flood	20	26	4.76	85
			Long	74 02 34							
1493	8.41	1/4 way across from Fort Lafayette	Lat	40 36 27		40	Flood	20	20	5.04	91
			Long	74 02 34							
1494	8.43	1/4 way across from Fort Lafayette	Lat	40 36 27		80	Flood	20	20	5.04	91
			Long	74 02 34							
1495	8.48	Half way across	Lat	40 36 25		1	Flood	20	26	4.78	85
			Long	74 02 48							
1496	8.50	" " "	Lat	40 36 25		40	Flood	20	20	4.92	89
			Long	74 02 48							
1497	8.52	" " "	Lat	40 36 25		80	Flood	20	20	4.92	89
			Long	74 02 48							
1498	8.57	3/4 way across from Fort Lafayette	Lat	40 36 23		1	Flood	20	26	4.83	86
			Long	74 03 02							
1499	8.59	3/4 way across from Fort Lafayette	Lat	40 36 23		40	Flood	20	20	5.00	90
			Long	74 03 02							
1500	9.01	3/4 way across from Fort Lafayette	Lat	40 36 23		80	Flood	20	20	5.00	90
			Long	74 03 02							
1501	9.06	200 feet off Fort Wadsworth	Lat	40 36 21		1	Flood	20	26	4.72	84
			Long	74 03 12							
1502	9.08	" " " " "	Lat	40 36 21		30	Flood	20	20	5.00	90
			Long	74 03 12							
1503	9.10	" " " " "	Lat	40 36 21		60	Flood	20	20	5.00	90
			Long	74 03 12							

Dissolved Oxygen. The Narrows-Cross-section between Forts Lafayette and Wadsworth. Sept. 26, 1911.

Low water occurred at Governors Island at 4.17 a.m. High water at 10.33 a.m. Low water at 4.57 p.m.

Flood currents began about 7 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1504	10.30	200 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 24	1	End of Flood	20	26	4.78	85
1505	10.32	" " " " "	Lat 40 36 29 Long 74 02 24	20	End of Flood	20	20	4.94	89
1506	10.34	" " " " "	Lat 40 36 29 Long 74 02 24	40	End of Flood	20	20	4.94	89
1507	10.39	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	1	End of Flood	20	26	4.90	87
1508	10.41	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	40	End of Flood	20	20	5.04	91
1509	10.43	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	80	End of Flood	20	20	5.04	91
1510	10.48	Half way across	Lat 40 36 25 Long 74 02 46	1	End of Flood	20	26	4.92	88
1511	10.50	" " "	Lat 40 36 25 Long 74 02 48	40	End of Flood	20	20	4.92	89
1512	10.52	" " "	Lat 40 36 25 Long 74 02 48	80	End of Flood	20	20	4.92	89
1513	10.57	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	1	End of Flood	20	26	5.00	89
1514	10.59	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	40	End of Flood	20	20	5.00	90
1515	11.01	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	80	End of Flood	20	20	5.00	90
1516	11.06	200 feet off Fort Wadsworth	Lat 40 36 21 Long 74 03 12	1	End of Flood	20	26	5.00	89
1517	11.08	" " " " "	Lat 40 36 21 Long 74 03 12	30	End of Flood	20	20	5.00	90
1518	11.10	" " " " "	Lat 40 36 21 Long 74 03 12	60	End of Flood	20	20	5.00	90

Dissolved Oxygen. The Narrows-Cross-section between Forts Lafayette and Wadsworth. Sept. 26, 1911.

Low water occurred at Governors Island at 4.17 a.m. High water at 10.33 a.m. Low water at 4.57 a.m.

Flood currents ended about 12 noon. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples		Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1519	12.30	200 feet off Fort Lafayette	Lat	40 36 29	1	Ebb	20	26	4.78	85
			Long	74 02 24						
1520	12.32	" " " " "	Lat	40 36 29	20	Ebb	20	20	4.78	86
			Long	74 02 24						
1521	12.34	" " " " "	Lat	40 36 29	40	Ebb	20	20	4.78	86
			Long	74 02 24						
1522	12.39	1/4 way across from Fort Lafayette	Lat	40 36 27	1	Ebb	20	26	4.90	87
			Long	74 02 34	40					
1523	12.41	1/4 way across from Fort Lafayette	Lat	40 36 27		Ebb	20	20	4.90	88
			Long	74 02 34						
1524	12.43	1/4 way across from Fort Lafayette	Lat	40 36 27	80	Ebb	20	20	4.90	88
			Long	74 02 34						
1525	12.48	Half way across	Lat	40 36 25	1	Ebb	20	26	4.78	85
			Long	74 02 48						
1526	12.50	" " "	Lat	40 36 25	40	Ebb	20	20	4.92	89
			Long	74 02 48						
1527	12.52	" " "	Lat	40 36 25	80	Ebb	20	20	4.92	89
			Long	74 02 48						
1528	12.57	3/4 way across from Fort Lafayette	Lat	40 36 23	1	Ebb	20	28	4.83	85
			Long	74 03 02						
1529	12.59	3/4 way across from Fort Lafayette	Lat	40 36 23	40	Ebb	20	20	4.83	87
			Long	74 03 02						
1530	1.01	3/4 way across from Fort Lafayette	Lat	40 36 23	80	Ebb	20	20	4.83	87
			Long	74 03 02						
1531	1.06	200 feet off Fort Wadsworth	Lat	40 36 21	1	Ebb	20	26	4.72	84
			Long	74 03 12						
1532	1.08	" " " " "	Lat	40 36 21	40	Ebb	20	20	4.87	86
			Long	74 03 12						
1533	1.10	" " " " "	Lat	40 36 21	80	Ebb	20	20	4.87	86
			Long	74 03 12						

Dissolved Oxygen. The Narrows-Cross-section between Forts Lafayette and Wadsworth. Sept. 26, 1911.

Low water occurred at Governors Island at 4.17 a.m. High water at 10.33 a.m. Low water at 4.57 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1534	2.30	200 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 24	1	Ebb	20	28	4.28	77
1535	2.32	" " " " "	Lat 40 36 29 Long 74 02 24	20	Ebb	20	24	4.51	81
1536	2.34	" " " " "	Lat 40 36 29 Long 74 02 24	40	Ebb	20	24	4.51	81
1537	2.39	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	1	Ebb	20	28	4.48	79
1538	2.41	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	40	Ebb	20	24	4.48	80
1539	2.43	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	80	Ebb	20	24	4.48	80
1540	2.46	Half way across	Lat 40 36 25 Long 74 02 48	1	Ebb	20	28	4.34	77
1541	2.50	" " "	Lat 40 36 25 Long 74 02 48	40	Ebb	20	24	4.34	78
1542	2.52	" " "	Lat 40 36 25 Long 74 02 48	80	Ebb	20	24	4.34	78
1543	2.57	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	1	Ebb	20	28	4.26	76
1544	2.59	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	40	Ebb	20	24	4.26	76
1545	3.01	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	80	Ebb	20	24	4.26	76
1546	3.06	200 feet off Fort Wadsworth	Lat 40 36 21 Long 74 03 18	1	Ebb	20	26	4.31	77
1547	3.08	" " " " "	Lat 40 36 21 Long 74 03 18	30	Ebb	20	24	4.31	77
1548	3.10	" " " " "	Lat 40 36 21 Long 74 03 18	60	Ebb	20	24	4.31	77

Low water occurred at Governors Island at 4.17 a.m. High water at 10.38 a.m. Low water at 4.57 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1549	4.30	200 feet off Fort Lafayette	Lat 40 36 29 Long 74 02 24	1	Ebb	20	30	3.96	70
1550	4.32	" " " " "	Lat 40 36 29 Long 74 02 24	20	Ebb	20	28	3.96	70
1551	4.34	" " " " "	Lat 40 36 29 Long 74 02 24	40	Ebb	20	28	3.96	70
1552	4.39	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	1	Ebb	20	30	4.06	72
1553	4.41	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	40	Ebb	20	28	4.06	72
1554	4.43	1/4 way across from Fort Lafayette	Lat 40 36 27 Long 74 02 34	80	Ebb	20	28	4.06	72
1555	4.48	Half way across	Lat 40 36 25 Long 74 02 48	1	Ebb	20	28	4.06	72
1556	4.50	" " "	Lat 40 36 25 Long 74 02 48	40	Ebb	20	26	4.06	72
1557	4.52	" " "	Lat 40 36 25 Long 74 02 48	80	Ebb	20	26	4.06	72
1558	4.57	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	1	Ebb	20	28	3.98	70
1559	4.59	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	40	Ebb	20	26	3.98	71
1560	5.01	3/4 way across from Fort Lafayette	Lat 40 36 23 Long 74 03 02	80	Ebb	20	26	3.98	71
1561	5.06	200 feet off Fort Wadsworth	Lat 40 36 21 Long 74 03 12	1	Ebb	20	28	3.89	69
1562	5.08	" " " " "	Lat 40 36 21 Long 74 03 12	30	Ebb	20	26	4.03	72
1563	5.10	" " " " "	Lat 40 36 21 Long 74 03 12	60	Ebb	20	26	4.03	72

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3581

Low water occurred at Governors Island at 4.17 a.m. High water at 10.58 a.m. Low water at 4.57 p.m. Ebb currents began about 10.50 p.m. Ebb currents ended 7.80 p.m. (estimated.)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1864	6.00	800 feet off Port Lafayette	Lat 40 36 29 Long 74 02 24	1	Ebb	20	30	3.69	68
1865	6.02	" " " " "	Lat 40 36 29 Long 74 02 24	20	Ebb	20	30	3.88	69
1866	6.04	" " " " "	Lat 40 36 29 Long 74 02 24	40	Ebb	20	30	3.88	69
1867	6.06	1/4 way across from Port Lafayette	Lat 40 36 27 Long 74 02 24	1	Ebb	20	30	3.78	67
1868	6.10	" " " "	Lat 40 36 27 Long 74 02 24	40	Ebb	20	30	3.91	69
1869	6.12	" " " "	Lat 40 36 27 Long 74 02 24	80	Ebb	20	30	3.92	69
1870	6.16	Half way across	Lat 40 36 25 Long 74 02 40	1	Ebb	20	30	3.91	69
1871	6.18	" " "	Lat 40 36 25 Long 74 02 40	40	Ebb	20	26	4.06	72
1872	6.20	" " "	Lat 40 36 25 Long 74 02 40	80	Ebb	20	26	4.06	72
1873	6.24	3/4 way across from Port Lafayette	Lat 40 36 23 Long 74 03 02	1	Ebb	20	30	3.94	69
1874	6.26	" " " "	Lat 40 36 23 Long 74 03 02	40	Ebb	20	26	3.98	71
1875	6.28	" " " "	Lat 40 36 23 Long 74 03 02	80	Ebb	20	26	3.98	71
1876	6.32	800 feet off Port Wadsworth	Lat 40 36 21 Long 74 03 12	1	Ebb	20	30	3.75	66
1877	6.34	" " " " "	Lat 40 36 21 Long 74 03 12	20	Ebb	20	26	3.89	69
1878	6.36	" " " " "	Lat 40 36 21 Long 74 03 12	60	Ebb	20	26	3.89	69

Ex. 74. p.156

Dissolved Oxygen. Hudson River Cross-section between Pier A, New York and C.R.R. of N.J. ferry, Jersey City. Sept. 20, 1911.

Low water occurred at Governors Island at 6.07 a.m. High water at 12.13 p.m.

Low water at 6.07 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1579	6.30	200 feet off Pier A.	Lat 40 42 16 Long 74 01 10	1	Ebb	20	42	3.01	52
1580	6.32	" " " " "	Lat 40 42 16 Long 74 01 10	20	Ebb	20	36	3.01	52
1581	6.34	" " " " "	Lat 40 42 16 Long 74 01 10	40	Ebb	20	34	3.01	52
1582	6.39	1/4 way across from Pier A.	Lat 40 42 17 Long 74 01 20	1	Ebb	20	42	3.08	53
1583	6.41	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Ebb	20	36	3.08	54
1584	6.43	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Ebb	20	34	3.08	54
1585	6.48	Half way across	Lat 40 42 19 Long 74 01 34	1	Ebb	20	42	3.19	55
1586	6.50	" " "	Lat 40 42 19 Long 74 01 34	20	Ebb	20	36	3.19	54
1587	6.52	" " "	Lat 40 42 19 Long 74 01 34	40	Ebb	20	36	3.19	54
1588	6.57	3/4 way across from Pier A.	Lat 40 42 21 Long 74 01 48	1	Ebb	20	42	3.12	54
1589	6.59	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Ebb	20	38	3.12	54
1590	7.01	" " " " " "	Lat 40 42 21 Long 74 01 48	40	Ebb	20	38	3.12	54
1591	7.06	200 feet off C.R.R. of N.J. ferry	Lat 40 42 22 Long 74 01 59	1	Ebb	20	42	3.06	53
1592	7.08	" " " " " "	Lat 40 42 22 Long 74 01 59	18	Ebb	20	38	3.19	55
1593	7.10	" " " " " "	Lat 40 42 22 Long 74 01 59	36	Ebb	20	38	3.19	55

PEOPLE OF STATE OF NEW YORK vs. STATE OF NEW JERSEY. 1915.

Dissolved Oxygen. Hudson River Cross-section between Pier A, New York and C.R.R. of N. J. ferry, Jersey City. September 28, 1911.

Low water occurred at Governors Island at 6.07 a.m. High water at 12.13 p.m. Low water at 6.07 p.m. Ebb currents ended about 10 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1594	8.30	200 feet off Pier A.	Lat 40 42 16 Long 74 01 10	1	Ebb	20	44	2.73	47
1595	8.32	200 " " " "	Lat 40 42 16 Long 74 01 10	20	Ebb	20	38	2.92	51
1596	8.34	200 " " " "	Lat 40 42 16 Long 74 01 10	40	Ebb	20	38	2.92	51
1597	8.39	1/4 way across from Pier A.	Lat 40 42 17 Long 74 01 20	1	Ebb	20	44	2.94	50
1598	8.41	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Ebb	20	40	2.94	51
1599	8.43	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Ebb	20	38	2.94	51
1600	8.48	Half way across	Lat 40 42 19 Long 74 01 34	1	Ebb	20	46	3.04	52
1601	8.50	" " "	Lat 40 42 19 Long 74 01 34	20	Ebb	20	42	3.04	52
1602	8.52	" " "	Lat 40 42 19 Long 74 01 34	40	Ebb	20	40	3.04	52
1603	8.57	3/4 way across from Pier A.	Lat 40 42 21 Long 74 01 48	1	Ebb	20	46	3.00	51
1604	8.59	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Ebb	20	42	3.12	54
1605	9.01	" " " " " "	Lat 40 42 21 Long 74 01 48	40	Ebb	20	40	3.12	54
1606	9.06	200 feet off C.R.R. of N.J. ferry	Lat 40 42 22 Long 74 01 59	1	Ebb	20	46	2.92	50
1607	9.08	" " " " " "	Lat 40 42 22 Long 74 01 59	15	Ebb	20	42	3.06	53
1608	9.10	" " " " " "	Lat 40 42 22 Long 74 01 59	25	Ebb	20	38	3.06	53

Dissolved Oxygen

Hudson River- Cross section between Pier A, New York and C.R.R.of N.J.Ferry, Jersey City — Sept. 28, 1911

Low water occurred at Governors Island at 6.07 a. m. High water at 12.15 p. m. Low water at 6.07 p.m.

Flood currents began about 10.30 a. m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1609	10.30	200 feet off Pier A	Lat 40 42 16 Long 74 01 10	1	Flood	20	38	2.87	50
1610	10.32	" " " " "	Lat 40 42 16 Long 74 01 10	20	Flood	20	34	3.01	53
1611	10.34	" " " " "	Lat 40 42 16 Long 74 01 10	40	Flood	20	34	3.01	53
1612	10.39	1/4 way across from Pier A	Lat 40 42 17 Long 74 01 20	1	Flood	20	38	3.08	53
1613	10.41	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Flood	20	36	3.08	54
1614	10.43	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Flood	20	34	3.08	54
1615	10.48	1/2 way across	Lat 40 42 19 Long 74 01 34	1	Flood	20	40	3.19	55
1616	10.50	" " "	Lat 40 42 19 Long 74 01 34	20	Flood	20	36	3.19	56
1617	10.52	" " "	Lat 40 42 19 Long 74 01 34	40	Flood	20	36	3.19	56
1618	10.57	3/4 way across from Pier A	Lat 40 42 21 Long 74 01 48	1	Flood	20	42	3.27	56
1619	10.59	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Flood	20	36	3.27	57
1620	11.01	" " " " " "	Lat 40 42 21 Long 74 01 48	40	Flood	20	38	3.27	57
1621	11.06	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	1	Flood	20	42	3.06	53
1622	11.08	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	15	Flood	20	38	3.19	55
1623	11.10	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	25	Flood	20	38	3.19	55

Dissolved Oxygen. Hudson River-Cross-section between Pier A, New York and C.R.R.ofN.J.Ferry,Jersey City. Sept.28,1911.

Low water occurred at Governors Island at 6.07 a.m. High water at 12.13 p.m. Low water at 6.07 p.m. Flood currents began about 10.30 a.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal currents	Temp water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation.
1624	12.30	200 feet off Pier A.	Lat 40 42 16 Long 74 01 10	1	Flood	20	36	3.14	55
1625	12.32	" " " " "	Lat 40 42 16 Long 74 01 10	20	Flood	20	34	3.28	57
1626	12.34	" " " " "	Lat 40 42 16 Long 74 01 10	40	Flood	20	34	3.28	57
1627	12.39	1/4 way across from Pier A.	Lat 40 42 17 Long 74 01 20	1	Flood	20	36	3.19	56
1628	12.41	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Flood	20	34	3.36	59
1629	12.43	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Flood	20	34	3.36	59
1630	12.48	Half way across	Lat 40 42 19 Long 74 01 34	1	Flood	20	36	3.27	57
1631	12.50	" " "	Lat 40 42 19 Long 74 01 34	20	Flood	20	34	3.41	60
1632	12.52	" " "	Lat 40 42 19 Long 74 01 34	40	Flood	20	32	3.41	60
1633	12.57	3/4 way across from Pier A.	Lat 40 42 21 Long 74 01 48	1	Flood	20	40	3.33	57
1634	12.59	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Flood	20	34	3.48	61
1635	1.01	" " " " " "	Lat 40 42 21 Long 74 01 48	40	Flood	20	32	3.48	61
1636	1.06	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	1	Flood	20	40	3.19	55
1637	1.08	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	15	Flood	20	34	3.33	58
1638	1.10	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	25	Flood	20	32	3.33	58

Dissolved Oxygen. Hudson River-Cross-section between Pier A, New York and C.R.R.ofN.J.Ferry,Jersey City. Sept.28, 1911.

Low water occurred at Governors Island at 5.07 a.m. High water at 12.13 p.m. Low water at 6.07 p.m. Flood currents ended about 8.30 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1639	2.30	200 feet off Pier A.	Lat 40 42 16 Long 74 01 10	1	Flood	20	32	3.28	56
1640	2.32	" " " " "	Lat 40 42 16 Long 74 01 10	20	Flood	20	28	3.41	60
1641	2.34	" " " " "	Lat 40 42 16 Long 74 01 10	40	Flood	20	28	3.41	60
1642	2.39	1/4 way across from Pier A.	Lat 40 42 17 Long 74 01 20	1	Flood	20	32	3.36	59
1643	2.41	" " " " " "	Lat 40 42 17 Long 74 01 20	20	Flood	20	28	3.50	62
1644	2.45	" " " " " "	Lat 40 42 17 Long 74 01 20	40	Flood	20	28	3.50	62
1645	2.48	Half way across	Lat 40 42 19 Long 74 01 34	1	Flood	20	32	3.41	60
1646	2.50	" " "	Lat 40 42 19 Long 74 01 34	20	Flood	20	28	3.55	63
1647	2.52	" " "	Lat 40 42 19 Long 74 01 34	40	Flood	20	28	3.55	63
1648	2.57	3/4 way across from Pier A.	Lat 40 42 21 Long 74 01 48	1	Flood	20	34	3.48	61
1649	2.59	" " " " " "	Lat 40 42 21 Long 74 01 48	20	Flood	20	28	3.62	64
1650	3.01	" " " " " "	Lat 40 42 21 Long 74 01 48	40	Flood	20	28	3.62	64
1651	3.04	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	1	Flood	20	36	3.47	60
1652	3.08	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	15	Flood	20	28	3.47	61
1653	3.10	200 feet off C.R.R.ofN.J. ferry.	Lat 40 42 22 Long 74 01 59	28	Flood	20	28	3.47	61

Dissolved Oxygen. Hudson River-Cross-section between Pier A, New York and C.R.R. of N.J.Ferry,Jersey City. Sept.28, 1911.

Low water occurred at Governors Island between 6.07 a.m. High water at 12.13 p.m.

Low water at 6.07 p.m. Ebb currents began about 4 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate		Exact ° ' "	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1654	4.30	200 feet off Pier A.	Lat	40 42 16	1	Ebb	20	32	3.01	88
			Long	74 01 10						
1655	4.32	" " " " "	Lat	40 42 16	20	Ebb	20	28	3.14	86
			Long	74 01 10						
1656	4.34	" " " " "	Lat	40 42 16	40	Ebb	20	28	3.14	86
			Long	74 01 10						
1657	4.39	1/4 way across from Pier A.	Lat	40 42 17	1	Ebb	20	34	3.08	84
			Long	74 01 20						
1658	4.41	" " " " " "	Lat	40 42 17	20	Ebb	20	28	3.22	87
			Long	74 01 20						
1659	4.43	" " " " " "	Lat	40 42 17	40	Ebb	20	28	3.22	87
			Long	74 01 20						
1660	4.48	Half way across	Lat	40 42 19	1	Ebb	20	26	3.12	84
			Long	74 01 34						
1661	4.50	" " "	Lat	40 42 19	20	Ebb	20	28	3.27	88
			Long	74 01 34						
1662	4.52	" " "	Lat	40 42 19	40	Ebb	20	28	3.27	88
			Long	74 01 34						
1663	4.57	3/4 way across from Pier A.	Lat	40 42 21	1	Ebb	20	26	3.19	86
			Long	74 01 48						
1664	4.59	" " " " " "	Lat	40 42 21	20	Ebb	20	28	3.33	89
			Long	74 01 48						
1665	5.01	" " " " " "	Lat	40 42 21	40	Ebb	20	28	3.33	89
			Long	74 01 48						
1666	5.06	200 feet off C.R.R.ofN.J. ferry.	Lat	40 42 22	1	Ebb	20	26	3.06	82
			Long	74 01 59						
1667	5.08	200 feet off C.R.R.ofN.J. ferry	Lat	40 42 22	18	Ebb	20	30	3.19	86
			Long	74 01 59						
1668	5.10	200 feet off C.R.R.ofN.J. ferry	Lat	40 42 22	28	Ebb	20	30	3.19	86
			Long	74 01 59						

Ex. 94. p.142

Dissolved Oxygen. Hudson River-Cross-section between Pier A, New York and C.R.R.of N.J.Ferry,Jersey City. Sept.30,1911.

Low water occurred at Governors Island at 6.07 a.m. High water at 12.12 p.m. Low water at 6.07 p.m. Ebb currents began about 4 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent ceturation
1669	6.00	200 feet off Pier A.	lat 40 42 16 Long 74 01 10	1	End of Ebb	20	30	3.73	47
1670	6.01	" " " " "	Lat 40 42 16 Long 74 01 10	20	"	20	32	3.92	51
1671	6.03	" " " " "	Lat 40 42 16 Long 74 01 10	40	"	20	31	2.92	51
1672	6.06	1/4 way across from Pier A.	Lat 40 42 17 Long 74 01 20	1	"	20	32	3.93	49
1673	6.07	" " " " " "	Lat 40 42 17 Long 74 01 20	20	"	20	32	2.94	52
1674	6.09	" " " " " "	Lat 40 42 17 Long 74 01 20	40	"	20	32	2.94	52
1675	6.13	Half way across	Lat 40 42 19 Long 74 01 24	1	"	20	32	3.00	52
1676	6.14	" " "	Lat 40 42 19 Long 74 01 24	20	"	20	34	3.00	53
1677	6.16	" " "	Lat 40 42 19 Long 74 01 24	40	"	20	34	3.00	53
1678	6.19	3/4 way across from Pier A.	Lat 40 42 21 Long 74 01 49	1	"	20	32	3.04	53
1679	6.21	" " " " " "	Lat 40 42 21 Long 74 01 49	20	"	20	34	3.04	53
1680	6.23	" " " " " "	Lat 40 42 21 Long 74 01 49	40	"	20	34	3.04	53
1681	6.27	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	1	"	20	32	2.92	51
1682	6.28	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	18	"	20	34	3.06	53
1683	6.30	200 feet off C.R.R.of N.J. ferry	Lat 40 42 22 Long 74 01 59	22	"	20	34	3.06	53

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept. 29, 1911.

Low water occurred at Governors Island at 6.07 a.m. High water at 12.52 p.m. Low water at 7.27 p.m. Slack water from 9 a.m. to 9.30 a.m.

Sample No.	Hour a.m.	Location of Sample — Approximate	Exact	Feet below surface	Tidal current	Temp water Deg. C	Per-cent land water	Oxygen c.c. per litre	Oxygen Per-cent satura-tion
1684	7.30	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	20	30	2.78	48
1685	7.32	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	"	20	29	2.87	51
1686	7.34	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	"	20	28	2.87	51
1687	7.38	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	"	20	30	2.80	49
1688	7.40	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	"	20	28	2.94	52
1689	7.42	1/4 way across from Pier 10, Manhattan	Lat 40 42 09 Long 74 00 17	40	"	20	28	2.94	52
1690	7.46	Half way across	Lat 40 42 05 Long 74 00 11	1	"	20	32	2.92	51
1691	7.48	" " "	Lat 40 42 05 Long 74 00 11	20	"	20	28	3.04	54
1692	7.50	" " "	Lat 40 42 05 Long 74 00 11	40	"	20	29	3.04	54
1693	7.54	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	1	"	20	32	2.84	50
1694	7.56	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	20	"	20	29	3.00	53
1695	7.58	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	38	"	20	28	3.00	53
1696	8.02	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	"	20	32	2.79	49
1697	8.04	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	"	20	28	2.92	52
1698	8.06	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	38	"	20	29	2.92	52

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept. 29, 1911.

Low water occurred at Governors Island at 6.57 a.m. High water at 12.53 p.m. Low water at 7.27 p.m. Flood currents began about 8.30 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
1699	9.30	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	20	34	3.01	53
1700	9.32	" " " " " "	Lat 40 42 09 Long 74 00 22	20	"	20	30	3.14	55
1701	9.34	" " " " " "	Lat 40 42 09 Long 74 00 22	30	"	20	30	3.14	55
1702	9.38	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	"	20	34	3.08	54
1703	9.40	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	"	20	30	3.19	56
1704	9.42	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	"	20	30	3.19	56
1705	9.46	Half way across	Lat 40 42 03 Long 74 00 11	1	"	20	34	3.19	56
1706	9.48	" " "	Lat 40 42 03 Long 74 00 11	20	"	20	30	3.19	56
1707	9.50	" " "	Lat 40 42 03 Long 74 00 11	40	"	20	30	3.19	56
1708	9.54	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	1	"	20	32	3.12	55
1709	9.56	3/4 way across from Pier 10, Manhattan	Lat 40 42 11 Long 74 00 05	20	"	20	30	3.12	55
1710	9.58	3/4 way across from Pier 10, Manhattan	Lat 40 41 57 Long 74 00 00	35	"	20	30	3.12	55
1711	10.02	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	"	20	32	2.73	48
1712	10.04	" " " " " "	Lat 40 41 57 Long 74 00 00	20	"	20	30	2.92	51
1713	10.06	" " " " " "	Lat 40 41 57 Long 74 00 00	35	"	20	30	2.92	51

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept. 29, 1911.

Low water occurred at Governors Island at 6.57 a.m. High water at 12.53 p.m. Low water at 7.27 p.m. Flood currents began about 8.30 a.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
1714	12.30	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Flood	20	30	3.14	55
1715	12.32	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	"	20	28	3.28	58
1716	12.34	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	"	20	28	3.28	58
1717	12.40	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	"	20	30	3.19	56
1718	12.42	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	"	20	28	3.36	60
1719	12.44	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	"	20	28	3.36	60
1720	12.49	Half way across	Lat 40 42 03 Long 74 00 11	1	"	20	30	3.33	59
1721	12.51	" " "	Lat 40 42 03 Long 74 00 11	20	"	20	28	3.33	59
1722	12.53	" " "	Lat 40 42 03 Long 74 00 11	40	"	20	28	3.33	59
1723	12.57	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	1	"	20	28	3.27	58
1724	12.59	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	20	"	20	28	3.27	58
1725	1.01	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	35	"	20	28	3.27	58
1726	1.05	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	"	20	28	3.06	54
1727	1.07	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	"	20	28	3.19	57
1728	1.09	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	35	"	30	28	3.19	57

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept.29, 1911.

Low water occurred at Governors Island at 6.57 a.m. High water at 12.53 p.m. Low water at 7.27 p.m. Flood currents ended about 2.30 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1729	2.30	100 feet off Pier 10, Manhattan	Lat	40 42 09		1	Flood	20	28	3.28	58
			Long	74 00 22							
1730	2.32	100 feet off Pier 10, Manhattan	Lat	40 42 09		20	Flood	20	28	3.28	58
			Long	74 00 22							
1731	2.34	100 feet off Pier 10, Manhattan	Lat	40 42 09		30	Flood	20	28	3.28	58
			Long	74 00 22							
1732	2.36	1/4 way across from Pier 10, Manhattan	Lat	40 42 07		1	Flood	20	28	3.36	60
			Long	74 00 17							
1733	2.40	1/4 way across from Pier 10, Manhattan	Lat	40 42 07		20	Flood	20	28	3.36	60
			Long	74 00 17							
1734	2.42	1/4 way across from Pier 10, Manhattan	Lat	40 42 07		40	Flood	20	28	3.36	60
			Long	74 00 17							
1735	2.46	Half way across	Lat	40 42 03		1	Flood	20	28	3.33	59
			Long	74 00 11							
1736	2.48	Half way across	Lat	40 42 03		20	Flood	20	28	3.33	59
			Long	74 00 11							
1737	2.50	Half way across	Lat	40 42 03		40	Flood	20	28	3.33	59
			Long	74 00 11							
1738	2.54	3/4 way across from Pier 10, Manhattan	Lat	40 42 00		1	Flood	20	28	3.27	58
			Long	74 00 05							
1739	2.56	3/4 way across from Pier 10, Manhattan	Lat	40 42 00		20	Flood	20	28	3.27	58
			Long	74 00 05							
1740	2.58	3/4 way across from Pier 10, Manhattan	Lat	40 42 00		35	Flood	20	28	3.27	58
			Long	74 00 05							
1741	3.02	100 feet off Pier 10, Brooklyn	Lat	40 41 57		1	Flood	20	28	3.19	57
			Long	74 00 00							
1742	3.04	100 feet off Pier 10, Brooklyn	Lat	40 41 57		20	Flood	20	28	3.19	57
			Long	74 00 00							
1743	3.06	100 feet off Pier 10, Brooklyn	Lat	40 41 57		35	Flood	20	28	3.19	57
			Long	74 00 00							

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept.29,1911.

Low water occurred at Governors Island at 6.57 a.m. High water at 12.53 p.m. Low water at 7.27 p.m. Ebb currents began about 3 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
1744	4.30	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	1	Ebb	20	30	2.87	51
1745	4.32	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	20	Ebb	20	28	2.87	51
1745	4.34	100 feet off Pier 10, Manhattan	Lat 40 42 09 Long 74 00 22	30	Ebb	20	28	2.87	51
1747	4.36	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	Ebb	20	30	2.94	51
1748	4.40	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	20	Ebb	20	28	3.08	55
1749	4.42	1/4 way across from Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	40	Ebb	20	28	3.08	55
1750	4.46	Half way across	Lat 40 42 05 Long 74 00 11	1	Ebb	20	28	3.04	54
1751	4.48	" " "	Lat 40 42 05 Long 74 00 11	20	Ebb	20	28	3.19	57
1752	4.50	" " "	Lat 40 42 05 Long 74 00 11	40	Ebb	20	28	3.19	57
1753	4.54	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	1	Ebb	20	28	3.00	53
1754	4.56	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	20	Ebb	20	28	3.12	55
1755	4.58	3/4 way across from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	35	Ebb	20	28	3.12	56
1756	5.02	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	1	Ebb	20	28	2.92	52
1757	5.04	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	20	Ebb	20	28	2.92	52
1758	5.06	100 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 74 00 00	36	Ebb	20	28	2.92	52

Dissolved Oxygen. East River-Cross-section between Pier 10, Manhattan and Pier 10, Brooklyn. Sept.29,1911.

Low water occurred at Governors Island at 6.57 a.m. High water at 12.53 p.m. Low water at 7.27 p.m. Ebb currents began about 3 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact				Feet below surface	Tidal currents	Temp water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
			°	'	"							
1759	6.00	100 feet off Pier 10, Manhattan	Lat	40	42	09	1	Ebb	20	30	2.73	48
			Long	74	00	22						
1760	6.01	100 feet off Pier 10, Manhattan	Lat	40	42	09	20	Ebb	20	28	2.87	51
			Long	74	00	22						
1761	6.02	100 feet off Pier 10, Manhattan	Lat	40	42	09	30	Ebb	20	28	2.87	51
			Long	74	00	22						
1762	6.06	1/4 way across from Pier 10, Manhattan	Lat	40	42	07	1	Ebb	20	30	2.94	52
			Long	74	00	17						
1763	6.07	1/4 way across from Pier 10, Manhattan	Lat	40	42	07	20	Ebb	20	28	2.94	52
			Long	74	00	17						
1764	6.09	1/4 way across from Pier 10, Manhattan	Lat	40	42	07	40	Ebb	20	28	2.94	52
			Long	74	00	17						
1765	6.13	Half way across	Lat	40	42	08	1	Ebb	20	30	3.04	54
			Long	74	00	11						
1766	6.14	" " "	Lat	40	42	08	20	Ebb	20	28	3.04	54
			Long	74	00	11						
1767	6.16	" " "	Lat	40	42	08	40	Ebb	20	28	3.04	54
			Long	74	00	11						
1768	6.20	3/4 way across from Pier 10, Manhattan	Lat	40	42	00	1	Ebb	20	30	3.00	53
			Long	74	00	05						
1769	6.21	3/4 way across from Pier 10, Manhattan	Lat	40	42	00	20	Ebb	20	28	3.00	53
			Long	74	00	05						
1770	6.23	3/4 way across from Pier 10, Manhattan	Lat	40	42	00	35	Ebb	20	28	3.00	53
			Long	74	00	05						
1771	6.27	100 feet off Pier 10, Brooklyn	Lat	40	41	57	1	Ebb	20	30	2.79	49
			Long	74	00	00						
1772	6.28	100 feet off Pier 10, Brooklyn	Lat	40	41	57	20	Ebb	20	28	2.92	52
			Long	74	00	00						
1773	6.30	100 feet off Pier 10, Brooklyn	Lat	40	41	57	35	Ebb	20	28	2.91	52
			Long	74	00	00						

PEOPLE OF STATE OF NEW YORK VS STATE OF NEW JERSEY. 3585

Dissolved Oxygen. Kill van Kull-Cross-section at New Brighton, Staten Island. Oct. 4, 1911.

High water occurred at Governors Island at 5.02 a.m. Low water at 11.18 a.m. High water at 5.20 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1774	7.30	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	1	Flood	18	30	4.10	70
1775	7.32	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	15	Flood	18	28	4.38	74
1776	7.34	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	30	Flood	18	28	4.65	79
1777	7.39	Midway across	Lat 40 39 57 Long 74 08 25	1	Flood	18	30	4.20	71
1778	7.41	" "	Lat 40 39 57 Long 74 08 25	30	Flood	18	28	4.49	76
1779	7.43	" "	Lat 40 39 57 Long 74 08 25	60	Flood	18	28	4.78	81
1780	7.48	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 08 26	1	Flood	18	32	4.17	71
1781	7.50	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 08 26	15	Flood	18	30	4.46	75
1782	7.52	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 08 26	75	Flood	18	30	4.72	80
1783	9.30	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	1	Ebb	18	24	4.38	74
1784	9.32	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	15	Ebb	17	34	4.28	73
1785	9.34	100 feet off Jersey Street, New Brighton	Lat 40 39 51 Long 74 08 24	30	Ebb	17	32	4.38	74
1786	9.39	Midway across	Lat 40 39 57 Long 74 08 25	1	Ebb	18	34	4.48	76
1787	9.41	" "	Lat 40 39 57 Long 74 08 25	30	Ebb	17	32	4.49	76
1788	9.43	" "	Lat 40 39 57 Long 74 08 25	60	Ebb	17	30	4.49	76

High water occurred at Governors Island at 8.02 a.m. Low water at 11.18 a.m. High water at 8.20 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen: c.c. per litre	Oxygen: Percent saturation
1789	9.42	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 75 05 26	1	Ebb	18	34	4.44	78
1790	9.50	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	15	Ebb	17	32	4.80	78
1791	9.52	" " " " " "	Lat 40 39 02 Long 74 05 26	25	Ebb	17	32	4.80	78
1792	11.30	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	1	Ebb	18	34	4.10	68
1793	11.32	" " " " "	Lat 40 38 51 Long 74 05 24	15	Ebb	18	34	4.26	73
1794	11.34	" " " " "	Lat 40 38 51 Long 74 05 24	30	Ebb	17.5	34	4.26	72
1795	11.39	Midway across	Lat 40 39 07 Long 74 05 25	1	Ebb	18	36	4.26	71
1796	11.41	" "	Lat 40 39 07 Long 74 05 25	30	Ebb	17.5	34	4.56	76
1797	11.43	" "	Lat 40 39 07 Long 74 05 25	40	Ebb	17.5	34	4.56	76
1798	11.49	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 75 05 26	1	Ebb	18	36	4.17	69
1799	11.50	" " " " " "	Lat 40 39 02 Long 75 05 26	15	Ebb	17.5	34	4.44	74
1800	11.52	" " " " " "	Lat 40 39 02 Long 75 05 26	25	Ebb	17.5	34	4.44	74
1801	1.30	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	1	Flood	18	34	4.10	68
1802	1.32	" " " " "	Lat 40 38 51 Long 74 05 24	15	Flood	17.5	32	4.38	73
1803	1.34	" " " " "	Lat 40 38 51 Long 74 05 24	30	Flood	17.5	32	4.38	73

Ex. 94. p.151

NOW

Dissolved Oxygen. Kill van Kull-Cross-section at New Brighton, Staten Island. Oct. 4, 1911.

High water occurred at Governors Island at 5.02 a.m. Low water at 11.18 a.m. High water at 5.20 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent saturation
1804	1.39	Midway across	Lat 40 38 57 Long 74 05 25	1	Flood	18	34	4.26	71
1805	1.41	" "	Lat 40 38 57 Long 74 05 25	20	Flood	17.5	30	4.55	76
1806	1.43	" "	Lat 40 38 57 Long 74 05 25	40	Flood	17.5	30	4.55	76
1807	1.48	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	1	Flood	18	32	4.44	75
1808	1.50	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	15	Flood	17.5	30	4.58	76
1809	1.52	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	25	Flood	17.5	30	4.58	76
1810	3.30	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	1	Flood	18.5	26	4.10	70
1811	3.32	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	15	Flood	18.5	26	4.38	74
1812	3.34	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	30	Flood	18.5	26	4.38	74
1813	3.39	Midway across	Lat 40 38 57 Long 74 05 25	1	Flood	18.5	28	4.17	71
1814	3.41	" "	Lat 40 38 57 Long 74 05 25	20	Flood	18.5	26	4.44	75
1815	3.43	" "	Lat 40 38 57 Long 74 05 25	40	Flood	18.5	26	4.44	75
1816	3.48	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	1	Flood	18.5	28	4.26	72
1817	3.50	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	15	Flood	18.5	26	4.40	74
1818	3.52	100 feet off Columbia Oil Co. pier (old)	Lat 40 39 02 Long 74 05 26	25	Flood	18.5	26	4.26	72

Dissolved Oxygen. Kill van Kull-Cross-section at New Brighton, Oct. 4, 1911.
Staten Island.

High water occurred at Governors Island at 6.02 a.m. Low water at 11.18 a.m. High water at 5.20 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact o ' "					C.C. per litre	Percent saturation
1819	5.30	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	1	Flood	18.5	28	4.38	74
1820	5.32	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 05 24	15	Flood	18.5	26	4.65	79
1821	5.34	100 feet off Jersey Street, New Brighton	Lat 40 38 51 Long 74 38 24	30	Flood	18.5	26	4.65	79
1822	5.39	Midway across	Lat 40 38 57 Long 74 05 25	1	Flood	18.5	26	4.44	75
1823	5.41	" "	Lat 40 38 57 Long 74 05 25	20	Flood	18.5	24	4.72	80
1824	5.43	" "	Lat 40 38 57 Long 74 05 25	40	Flood	18.5	24	4.72	80
1825	5.48	100 feet off Columbia Oil Co. pier	Lat 40 39 02 Long 74 05 26	1	Flood	18.5	26	4.54	77
1826	5.50	100 feet off Columbia Oil Co. pier	Lat 40 39 02 Long 74 05 26	15	Flood	18.5	24	4.69	79
1827	5.52	100 feet off Columbia Oil Co. pier	Lat 40 39 02 Long 74 05 26	25	Flood	18.5	24	4.69	79

6698 "JERSEY" VS. STATE OF NEW YORK AND STATE OF NEW JERSEY.

Dissolved Oxygen Newark bay-Cross-section just below C.R.R. of N.J. trestle. Oct. 6, 1911.

High water occurred at Governors Island at 6.20 a.m. Low water at 12.45 p.m. High water at 6.38 p.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent saturation
1828	8.00	300 feet off east shore (Bayonne)	Lat 40 39 17 Long 74 08 27	1	Ebb	15.5	40	3.88	62
1829	8.02	" " " " " "	Lat 40 39 17 Long 74 08 27	10	Flood	16	32	3.88	64
1830	8.06	In channel near draw	Lat 40 39 17 Long 74 08 46	1	Ebb	15.5	40	3.84	61
1831	8.08	" " " "	Lat 40 39 17 Long 74 08 46	15	Flood	16	36	4.12	66
1832	8.10	" " " "	Lat 40 39 17 Long 74 08 46	30	Flood	16	36	3.70	60
1833	8.14	Half way across bay	Lat 40 39 17 Long 74 09 14	1	Ebb	15.5	40	3.89	62
1834	8.16	" " " "	Lat 40 39 17 Long 74 09 14	8	Ebb	16	38	3.89	63
1835	8.20	3/4 way across from east shore	Lat 40 39 17 Long 74 09 40	1	Ebb	15.5	40	3.83	61
1836	8.22	" " " " " "	Lat 40 39 17 Long 74 09 40	8	Ebb	16	38	3.83	62
1837	8.26	300 feet off west shore	Lat 40 39 18 Long 74 10 02	1	Ebb	15.5	40	3.92	62
1838	8.28	" " " " "	Lat 40 39 18 Long 74 10 02	8	Ebb	15.5	38	3.92	62
1839	10.00	300 feet off east shore	Lat 40 39 17 Long 74 08 27	1	Ebb	15.5	44	4.48	71
1840	10.02	" " " " "	Lat 40 39 17 Long 74 08 27	9	Ebb	16	40	4.48	71
1841	10.06	In channel near draw	Lat 40 39 17 Long 74 08 46	1	Ebb	16	40	4.26	68
1842	10.08	" " " "	Lat 40 39 17 Long 74 08 46	15	Ebb	16	40	4.40	70
1843	10.10	" " " "	Lat 40 39 17 Long 74 08 46	30	Ebb	16	40	4.26	68

Dissolved Oxygen. Newark Bay-Cross-section just below C.R.R. of N.J. trestle. Oct. 6, 1911.

High water occurred at Governors Island at 6.20 a.m. Low water at 12.48 p.m. High water at 6.38 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact:	o	'	"	Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percentage saturation
1844	10.14	Half way across bay	Lat	40	39	17	1	Ebb	15.5	40	4.17	66
			Long	74	09	14						
1845	10.16	" " " "	Lat	40	39	17	7	Ebb	16	40	4.17	66
			Long	74	09	14						
1846	10.20	3/4 way across from east shore	Lat	40	39	17	1	Ebb	15.5	40	4.18	65
			Long	74	09	40						
1847	10.22	" " " " " "	Lat	40	39	17	7	Ebb	16	40	4.10	65
			Long	74	09	40						
1848	10.26	300 feet off west shore	Lat	40	39	18	1	Ebb	15.5	40	4.06	65
			Long	74	10	02						
1849	10.28	" " " " "	Lat	40	39	18	7	Ebb	15.5	40	4.06	65
			Long	74	10	02						
1850	12.00	300 feet off east shore	Lat	40	39	17	1	Ebb	16	46	4.18	66
			Long	74	08	27						
1851	12.02	" " " " "	Lat	40	39	17	8	Ebb	16	44	4.32	69
			Long	74	08	27						
1852	12.04	In channel near draw	Lat	40	39	17	1	Ebb	16	46	4.26	68
			Long	74	08	46						
1853	12.06	" " " "	Lat	40	39	17	15	Ebb	16	44	4.26	68
			Long	74	08	46						
1854	12.08	" " " "	Lat	40	39	17	30	Ebb	16	42	4.26	68
			Long	74	08	46						
1855	12.12	Half way across bay	Lat	40	39	17	1	Ebb	16	48	4.44	70
			Long	74	09	14						
1856	12.14	" " " "	Lat	40	39	17	6	Ebb	16	46	4.58	73
			Long	74	09	14						
1857	12.18	3/4 way across from east shore	Lat	40	39	17	1	Ebb	16	48	4.51	71
			Long	74	09	40						
1858	12.20	" " " " " "	Lat	40	39	17	6	Ebb	16	48	4.38	70
			Long	74	09	40						

Dissolved Oxygen. Remark boy Upper section just below G.W.B. of N. J. Terminal. October 6, 1911.

High water occurred at Governors Island at 6.50 a.m. Low water at 12.48 p.m. High water at 6.55 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen percent saturation
1859	12.24	800 feet off west shore	Lat 40 39 18 Long 74 10 02	1	Ebb	16	48	4.48	71
1860	12.26	" " " " "	Lat 40 39 18 Long 74 10 02	6	Ebb	16	48	4.48	71
1861	2.00	800 feet off east shore	Lat 40 39 17 Long 74 08 27	1	Ebb	16	54	4.48	70
1862	2.02	" " " " "	Lat 40 39 17 Long 74 08 27	8	Ebb	16	54	4.48	70
1863	2.04	In channel near draw	Lat 40 39 17 Long 74 08 46	1	Ebb	16	54	4.26	67
1864	2.06	" " " "	Lat 40 39 17 Long 74 08 46	18	Ebb	16	52	4.26	67
1865	2.08	" " " "	Lat 40 39 17 Long 74 08 46	30	Ebb	16	50	4.26	67
1866	2.10	Half way across	Lat 40 39 17 Long 74 09 14	1	Ebb	16	54	4.17	65
1867	2.14	" " "	Lat 40 39 17 Long 74 09 14	6	Ebb	16	54	4.17	65
1868	2.16	3/4 way across from east shore	Lat 40 39 17 Long 74 09 40	1	Ebb	16	54	4.10	64
1869	2.20	" " " " " "	Lat 40 39 17 Long 74 09 40	5	Ebb	16	54	4.10	64
1870	2.24	300 feet off west shore	Lat 40 39 18 Long 74 10 02	1	Ebb	16	54	4.20	66
1871	2.26	" " " " "	Lat 40 39 18 Long 74 10 02	6	Ebb	16	54	4.20	66
1872	2.30	300 feet off east shore	Lat 40 39 17 Long 74 08 27	1	Flood	15.5	48	3.88	61
1873	2.32	" " " " "	Lat 40 39 17 Long 74 08 27	8	Flood	15.5	46	3.88	61

Dissolved Oxygen. Newark Bay-Cross-section just below Oct. 6, 1911.
G.R.R. of R.R. trestle.

High water occurred at Governors Island at 6.20 a.m. Low water at 12.48 p.m. High water at 6.58 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1874	3.36	In channel, near dres	Lat 40 39 17 Long 74 08 46	1	Flood	18.8	48	3.84	60
1875	3.38	" " " "	Lat 40 39 17 Long 74 08 46	15	Flood	18.8	46	3.84	60
1876	3.40	" " " "	Lat 40 39 17 Long 74 08 46	30	Flood	18.8	44	4.12	64
1877	3.44	Half way across	Lat 40 39 19 Long 74 09 14	1	Flood	18.8	48	3.89	61
1878	3.46	" " "	Lat 40 39 17 Long 74 09 14	7	Flood	18.8	44	3.89	61
1879	3.50	3/4 way across	Lat 40 39 17 Long 74 09 40	1	Flood	18.6	46	3.83	60
1880	3.52	" " "	Lat 40 39 17 Long 74 09 40	7	Flood	18.6	46	3.83	60
1881	3.54	300 feet off west shore	Lat 40 39 18 Long 74 10 02	1	Flood	18.8	46	3.98	62
1882	3.58	" " " " "	Lat 40 39 18 Long 74 10 02	7	Flood	18.8	46	3.98	62
1883	3.00	300 feet off east shore	Lat 40 39 17 Long 74 08 29	1	Flood	18.6	40	3.88	62
1884	3.02	" " " " "	Lat 40 39 17 Long 74 08 29	8	Flood	18.8	40	3.88	62
1885	3.06	In channel, near dres	Lat 40 39 17 Long 74 08 46	1	Flood	18.8	40	3.72	60
1886	3.08	" " " "	Lat 40 39 17 Long 74 08 46	15	Flood	18.8	38	3.84	61
1887	3.10	" " " "	Lat 40 39 17 Long 74 08 46	30	Flood	18.8	38	3.98	62
1888	3.14	Half way across	Lat 40 39 17 Long 74 09 14	1	Flood	18.8	38	3.61	57
1889	3.16	" " "	Lat 40 39 17 Long 74 09 14	8	Flood	18.8	38	3.61	57

Dissolved Oxygen. Newark bay-Cross-section just below C.R.R. of N.J. trestle. Oct. 6, 1911.

High water occurred at Governors Island at 6.20 a.m. Low water at 12.45 p.m. High water at 6.35 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact o ' "					C.C. per litre	Percent saturation
1890	5.20	3/4 way across	Lat. 40 39 17 Long 74 09 40	1	Flood	15.5	38	3.55	56
1891	5.22	" " "	Lat 40 39 17 Long 74 09 40	8	Flood	15.5	38	3.55	56
1892	5.26	300 feet off west shore	Lat 40 39 18 Long 74 10 02	1	Flood	15.5	38	3.54	56
1893	5.28	" " " " "	Lat 40 39 18 Long 74 10 02	8	Flood	15.5	38	3.54	56

Dissolved Oxygen. East River-Cross-section between Lawrence Pt.and Stony Pt. Oct.11,1911.

High water occurred at Governors Island at 9.50 a.m.-Hell Gate-Low water at 5.15a.m. High water at 11.40 a.m. Low water at 6.10 p.m. Flood currents began about 7.15 a.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
1894	7.50	By Buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	1	Flood	16.5	26	3.28	55
1895	7.52	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Flood	16.5	26	3.28	55
1896	7.54	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Flood	16.5	26	3.28	55
1897	7.58	Half way across	Lat 40 47 45 Long 73 54 31	1	Flood	16.5	26	3.27	55
1898	8.00	" " "	Lat 40 47 45 Long 73 54 31	35	Flood	16.5	26	3.27	55
1899	8.02	" " "	Lat 40 47 45 Long 73 54 31	70	Flood	16.5	26	3.27	55
1900	8.06	200 feet off E.134 St.ferry, (Stony Pt.)	Lat 40 47 56 Long 73 54 31	1	Flood	16.5	26	3.33	56
1901	8.08	200 feet off E.134 St.ferry, (Stony Pt.)	Lat 40 47 56 Long 73 54 31	35	Flood	16.5	26	3.33	56
1902	8.10	200 feet off E.134 St.ferry, (Stony Pt.)	Lat 40 47 56 Long 73 54 31	70	Flood	16.5	26	3.33	56
1903	10.00	By Buoy 7 near Lawrence Point	Lat 40 47 34 Long 73 54 30	1	Flood	16.5	30	3.14	52
1904	10.02	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Flood	16.5	28	3.28	54
1905	10.04	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Flood	16.5	28	3.28	54
1906	10.08	Half way across	Lat 40 47 45 Long 73 54 31	1	Flood	16.5	30	3.12	52
1907	10.10	" " "	Lat 40 47 45 Long 73 54 31	35	Flood	16.5	28	3.41	56
1908	10.12	" " "	Lat 40 47 45 Long 73 54 31	70	Flood	16.5	28	3.41	56

Dissolved Oxygen. East River-Cross-section between Lawrence Pt. and Stony Pt. Oct. 11, 1911.

High water occurred at Governors Island at 9.50 a.m. Hell Gate-Low water at 5.15 a.m.

High water at 11.40 a.m. Low water at 6.10 p.m. Flood currents began about 7.15 a.m.

Sample No.	Hour a.m.	Location of samples			Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "						C.C. per litre	Percent saturation
1909	10.16	200 feet off E.134 St.ferry	Lat 40 47 56 Long 73 54 31	1	Flood	16.5	30	3.19	53
1910	10.18	" " " " " " "	Lat 40 47 56 Long 73 54 31	35	Flood	16.5	28	3.33	55
1911	10.20	" " " " " " "	Lat 40 47 56 Long 73 54 31	70	Flood	16.5	28	3.33	55

Dissolved Oxygen. East River-Cross-section between Lawrence Pt.and Stony Pt. Oct. 11, 1911.

Hell Gate - Low water occurred at 5.15 a.m. High water at 11.40 a.m. Flood currents began about 7.15 a.m. Flood currents ended about 12.15 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent saturation
1912	12.00	By Buoy 7 near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	1	Flood	16.5	36	3.14	51
1913	12.02	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Flood	16	32	3.28	54
1914	12.04	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Flood	16	32	3.28	54
1915	12.08	Half way across	Lat 40 47 45 Long 73 54 31	1	Flood	16.5	36	3.12	50
1916	12.10	" " "	Lat 40 47 45 Long 73 54 31	35	Flood	16	32	3.41	56
1917	12.12	" " "	Lat 40 47 45 Long 73 54 31	70	Flood	16	32	3.41	56
1918	12.16	200 feet off E.134 St.ferry	Lat 40 47 56 Long 73 54 31	1	Flood	16.5	36	3.19	51
1919	12.18	" " " " " " "	Lat 40 47 56 Long 73 54 31	35	Flood	16	32	3.33	55
1920	12.20	" " " " " " "	Lat 40 47 56 Long 73 54 31	70	Flood	16	32	3.33	55
1921	2.00	By Buoy 7 near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	1	Ebb	16.5	28	3.28	54
1922	2.02	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Ebb	16.5	28	3.28	54
1923	2.04	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Ebb	16.5	28	3.28	54
1924	2.08	Half way across	Lat 40 47 45 Long 73 54 31	1	Ebb	16.5	28	3.29	54
1925	2.10	" " "	Lat 40 47 45 Long 73 54 31	35	Ebb	16.5	28	3.41	56
1926	2.12	" " "	Lat 40 47 45 Long 73 54 31	70	Ebb	16.5	28	3.41	56

Dissolved Oxygen. Hnat River-Cross-section between Lawrence Pt.and Stony Pt. Oct 11. 1911.

Hell Gate - Low water occurred at 8.18 a.m. High water at 11.40 a.m. Flood currents began about 7.15 a.m. Flood currents ended about 12.18 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
1927	2.16	200 feet off E.134 St.ferry	Lat 40 47 56 Long 73 54 31	1	Ebb	16.8	28	3.33	88
1928	2.18 " " " " " " "		Lat 40 47 56 Long 73 54 31	35	Ebb	16.8	28	3.33	88
1929	2.20 " " " " " " "		Lat 40 47 56 Long 73 54 31	70	Ebb	16.8	28	3.33	88

Ex. 94. P. 162

Dissolved Oxygen. Hast River-Cross-section between Lawrence Pt and Stony Pt. Oct. 11, 1911.

Hell Gate - High water occurred at 11.40 a.m. Low water at 6.14 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per cent land water	Oxygen C.C. per litre	Oxygen Percentage saturation
1930	4.00	By Buoy 7 near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	1	Ebb	16.	24	3.58	89
1931	4.02	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Ebb	16	24	3.68	92
1932	4.04	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Ebb	16	24	3.69	92
1933	4.08	Half way across	Lat 40 47 48 Long 73 54 30	1	Ebb	16	24	3.70	92
1934	4.10	" " "	Lat 40 47 48 Long 73 54 31	25	Ebb	16	24	3.56	84
1935	4.12	" " "	Lat 40 47 48 Long 73 54 31	70	Ebb	16	24	3.54	84
1936	4.16	200 feet off E.134 St.ferry	Lat 40 47 56 Long 73 54 31	1	Ebb	16	24	3.61	90
1937	4.18	" " " " " " "	Lat 40 47 56 Long 73 54 31	25	Ebb	16	24	3.75	93
1938	4.20	" " " " " " "	Lat 40 47 56 Long 73 54 31	70	Ebb	16	24	3.75	93
1939	5.00	By Buoy 7 near Lawrence Pt.	Lat 40 47 34 Long 73 54 30	1	Ebb	16	24	3.58	89
1940	5.02	" " " " " "	Lat 40 47 34 Long 73 54 30	20	Ebb	16	24	3.69	92
1941	5.04	" " " " " "	Lat 40 47 34 Long 73 54 30	40	Ebb	16	24	3.69	92
1942	5.08	Half way across	Lat 40 47 48 Long 73 54 31	1	Ebb	16	24	3.70	92
1943	5.10	" " "	Lat 40 47 48 Long 73 54 31	25	Ebb	16	24	3.54	84
1944	5.12	" " "	Lat 40 47 48 Long 73 54 31	70	Ebb	16	24	3.54	84

Dissolved Oxygen. Hudson River-Cross-section between Oct. 11, 1911.
Lawrence Pt. and Stony Pt.

Hell Gate- High water occurred at 11.40 a.m. Low water at 6.30 p.m. Ebb currents began about 12.30 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate		Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent saturation
1948	5.16	200 feet off S.124 St. ferry	Lat 40 47 86 Long 73 54 31	1	Ebb	16	24	3.61	60
1946	5.18	" " " " " " "	Lat 40 47 86 Long 73 54 31	30	Ebb	16	24	3.75	63
1947	5.20	" " " " " " "	Lat 40 47 86 Long 73 54 31	70	Ebb	16	24	3.78	63

Rm. 94, P. 164

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 9610

Dissolved Oxygen. Hudson River Cross-section at Mt. St. Vincent. Oct. 13, 1911.

Low water occurred at Governors Island at 5.15 a.m. High water at 11.32 a.m.

Mt. St. Vincent - Low water at 7.15 a.m. High water at 1.45 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
1948	7.45	500 feet off Mt. St. Vincent	Lat 40 54 50 Long 73 54 49	1	Ebb	15.5	80	5.74	84
1949	7.47	" " " " " "	Lat 40 54 50 Long 73 54 49	20	Ebb	15	60	5.19	78
1950	7.49	" " " " " "	Lat 40 54 50 Long 73 54 49	40	Ebb	15	58	5.19	78
1951	7.53	1/4 way across from east shore	Lat 40 54 50 Long 73 54 59	1	Ebb	15.5	80	5.83	85
1952	7.55	" " " " " "	Lat 40 54 50 Long 73 54 59	20	Ebb	15	60	5.28	79
1953	7.57	" " " " " "	Lat 40 54 50 Long 73 54 59	40	Ebb	15	58	5.28	79
1954	8.01	Half way across	Lat 40 54 50 Long 73 55 15	1	Ebb	15.5	78	5.88	86
1955	8.03	" " "	Lat 40 54 50 Long 73 55 15	20	Ebb	15	68	5.60	83
1956	8.05	" " "	Lat 40 54 50 Long 73 55 15	35	Ebb	15	66	5.60	84
1957	8.09	3/4 way across from east shore	Lat 40 54 50 Long 73 55 30	1	Ebb	15.5	76	5.97	88
1958	8.11	" " " " " "	Lat 40 54 50 Long 73 55 30	10	Ebb	15	72	5.68	84
1959	8.13	" " " " " "	Lat 40 54 50 Long 73 55 30	20	Ebb	15	72	5.68	84
1960	8.17	500 feet off west shore	Lat 40 54 50 Long 73 55 42	1	Ebb	15.5	76	5.94	87
1961	8.19	" " " " "	Lat 40 54 50 Long 73 55 42	10	Ebb	15.5	74	5.65	83
1962	8.21	" " " " "	Lat 40 54 50 Long 73 55 42	15	Ebb	15.5	74	5.65	83

Dissolved Oxygen. Hudson River Cross-section at Mt. St. Vincent. Oct. 13, 1911.

Mt. St. Vincent- Low water occurred at 7.15 a.m. High water at 1.45 p.m. Ebb currents ended about 10.15

Sample No.	Hour a.m.	Location of Samples			Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact							
1963	9.45	500 feet off Mt. St. Vincent	Lat 40 54 50 Long 73 54 49		1	Ebb	15.5	76	5.74	84
1964	9.47	" " " " " "	Lat 40 54 50 Long 73 54 49		20	Ebb	15.5	68	5.19	77
1965	9.49	" " " " " "	Lat 40 54 50 Long 73 54 49		40	Ebb	15.5	68	5.19	77
1966	9.53	1/4 way across from east shore	Lat 40 54 50 Long 73 54 59		1	Ebb	15.5	76	5.83	86
1967	9.55	" " " " " "	Lat 40 54 50 Long 73 54 59		20	Ebb	15.5	68	5.28	79
1968	9.57	" " " " " "	Lat 40 54 50 Long 73 54 59		40	Ebb	15.5	68	5.28	79
1969	10.01	Half way across	Lat 40 54 50 Long 73 55 15		1	Ebb	15.5	76	5.88	87
1970	10.03	" " "	Lat 40 54 50 Long 73 55 15		20	Ebb	15.5	68	5.60	84
1971	10.05	" " "	Lat 40 54 50 Long 73 55 15		35	Ebb	15.5	68	5.60	84
1972	10.09	3/4 way across from east shore	Lat 40 54 50 Long 73 55 30		1	Ebb	15.5	76	5.97	88
1973	10.11	" " " " " "	Lat 40 54 50 Long 73 55 30		10	Ebb	15.5	70	5.68	85
1974	10.13	" " " " " "	Lat 40 54 50 Long 73 55 30		20	Ebb	15.5	70	5.68	85
1975	10.17	500 feet off west shore	Lat 40 54 50 Long 73 55 42		1	Ebb	15.5	76	5.94	87
1976	10.19	" " " " "	Lat 40 54 50 Long 73 55 42		10	Ebb	15.5	72	5.65	84
1977	10.21	" " " " "	Lat 40 54 50 Long 73 55 42		15	Ebb	15.5	70	5.65	84

Dissolved Oxygen. Hudson River-Cross-section at Mt.St.Vincent. Oct. 13, 1911.

Mt. St. Vincent-Low water occurred at 7.15 a.m. High water at 1.45 p.m. Flood currents began about 10.30 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent satura-tion
1978	11.45	500 feet off Mt.St.Vincent	Lat 40 54 50 Long 73 54 49	1	Flood	15.5	70	4.94	74
1979	11.47	" " " " " "	Lat 40 54 50 Long 73 54 49	20	Flood	15.5	66	4.78	73
1980	11.49	" " " " " "	Lat 40 54 50 Long 73 54 49	40	Flood	15.5	64	4.78	73
1981	11.53	1/4 way across from east shore	Lat 40 54 50 Long 73 54 59	1	Flood	15.5	70	5.00	75
1982	11.55	" " " " " "	Lat 40 54 50 Long 73 54 59	20	Flood	15.5	66	4.87	74
1983	11.57	" " " " " "	Lat 40 54 50 Long 73 54 59	40	Flood	15.5	64	4.87	74
1984	12.01 p.m.	Half way across	Lat 40 54 50 Long 73 55 15	1	Flood	15.5	72	5.04	75
1985	12.03	" " " "	Lat 40 54 50 Long 73 55 15	20	Flood	15.5	66	4.90	74
1986	12.05	" " "	Lat 40 54 50 Long 73 55 15	35	Flood	15.5	66	4.90	74
1987	12.09	3/4 way across from east shore	Lat 40 54 50 Long 73 55 30	1	Flood	15.5	72	5.11	76
1988	12.11	" " " " " "	Lat 40 54 50 Long 73 55 30	10	Flood	15.5	68	5.00	75
1989	12.13	" " " " " "	Lat 40 54 50 Long 73 55 30	20	Flood	15.5	68	5.00	75
1990	12.17	500 feet off west shore	Lat 40 54 50 Long 73 55 42	1	Flood	15.5	72	5.22	78
1991	12.19	" " " " "	Lat 40 54 50 Long 73 55 42	10	Flood	15.5	70	5.07	76
1992	12.21	" " " " "	Lat 40 54 50 Long 73 55 42	15	Flood	15.5	70	5.07	76

Dissolved Oxygen. Hudson River-Cross-section at Mt.St.Vincent. Oct.13,1911.

Mt.St.Vincent-Low water occurred at 7.15 a.m. High water at 1.45 p.m. Flood currents began about 10.30 a.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen. C.C. per litre	Oxygen. Percent saturation
1993	2.00	800 feet off Mt.St.Vincent	Lat 40 54 50 Long 73 54 49	1	Flood	15.5	64	4.78	73
1994	2.02	" " " " " "	Lat 40 54 50 Long 73 54 49	20	Flood	15.5	60	4.38	67
1995	2.04	" " " " " "	Lat 40 54 50 Long 73 54 49	40	Flood	15.5	60	4.38	67
1996	2.08	1/4 way across from east shore	Lat 40 54 50 Long 73 54 59	1	Flood	15.5	64	4.87	74
1997	2.10	" " " " " "	Lat 40 54 50 Long 73 54 59	20	Flood	15.5	60	4.44	68
1998	2.12	" " " " " "	Lat 40 54 50 Long 73 54 59	40	Flood	15.5	60	4.44	68
1999	2.16	Half way across	Lat 40 54 50 Long 73 55 15	1	Flood	15.5	64	4.90	74
2000	2.18	" " "	Lat 40 54 50 Long 73 55 15	20	Flood	15.5	60	4.48	68
2001	2.20	" " "	Lat 40 54 50 Long 73 55 15	35	Flood	15.5	60	4.48	68
2002	2.24	3/4 way across from east shore	Lat 40 54 50 Long 73 55 30	1	Flood	15.5	64	5.00	76
2003	2.26	" " " " " "	Lat 40 54 50 Long 73 55 30	10	Flood	15.5	60	4.55	70
2004	2.28	" " " " " "	Lat 40 54 50 Long 73 55 30	20	Flood	15.5	60	4.55	70
2005	2.32	800 feet off west shore	Lat 40 54 50 Long 73 55 42	1	Flood	15.5	68	5.07	77
2006	2.34	" " " " "	Lat 40 54 50 Long 73 55 42	10	Flood	15.5	62	4.64	71
2007	2.36	" " " " "	Lat 40 54 50 Long 73 55 42	18	Flood	15.5	60	4.64	71

Dissolved Oxygen. Hudson River-Cross-section at Mt.St.Vincent. Oct. 13,1911.

Mt.St.Vincent- High water occurred at 1.48 p.m. Ebb currents began about 3.15 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact				Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
				°	'	"						
2008	4.00	500 feet off Mt.St.Vincent	Lat	40	54	50	1	Ebb	16	64	4.78	73
			Long	73	54	49						
2009	4.02	" " " " " "	Lat	40	54	50	20	Ebb	16	60	4.78	74
			Long	73	54	49						
2010	4.04	" " " " " "	Lat	40	54	50	40	Ebb	16	60	4.94	76
			Long	73	54	49						
2011	4.06	1/4 way across from east shore	Lat	40	54	50	1	Ebb	16	64	4.87	74
			Long	73	54	59						
2012	4.10	" " " " " "	Lat	40	54	50	20	Ebb	16	60	4.87	75
			Long	73	54	59						
2013	4.12	" " " " " "	Lat	40	54	50	40	Ebb	16	60	4.87	75
			Long	73	54	59						
2014	4.16	Half way across	Lat	40	54	50	1	Ebb	16	64	5.04	76
			Long	73	55	15						
2015	4.18	" " "	Lat	40	54	50	20	Ebb	16	60	5.04	77
			Long	73	55	15						
2016	4.20	" " "	Lat	40	54	50	35	Ebb	16	60	5.04	77
			Long	73	55	15						
2017	4.24	3/4 way across from east shore	Lat	40	54	50	1	Ebb	16	64	5.11	77
			Long	73	55	30						
2018	4.26	" " " " " "	Lat	40	54	50	10	Ebb	16	60	5.00	77
			Long	73	55	30						
2019	4.28	" " " " " "	Lat	40	54	50	20	Ebb	16	60	5.00	77
			Long	73	55	30						
2020	4.32	500 feet off west shore	Lat	40	54	50	1	Ebb	16	68	5.22	79
			Long	73	55	42						
2021	4.34	" " " " "	Lat	40	54	50	10	Ebb	16	60	5.07	78
			Long	73	55	42						
2022	4.36	" " " " "	Lat	40	54	50	15	Ebb	16	60	5.07	78
			Long	73	55	42						

Dissolved Oxygen. Hudson River-Cross-section at Mt.St.Vincent. Oct. 18, 1911.

Mt.St.Vincent- High water occurred at 1.48 p.m. Ebb currents began about 3.15 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen c.c. per litre	Oxygen Percent ature-tion
2083	3.15	800 feet off Mt.St.Vincent	Lat 40 54 50 Long 73 54 49	1	Ebb	16	68	5.06	76
2084	3.17	" " " " " "	Lat 40 54 50 Long 73 54 49	20	Ebb	16	68	5.06	76
2085	3.19	" " " " " "	Lat 40 54 50 Long 73 54 49	40	Ebb	16	68	5.06	76
2086	3.23	1/4 way across from east shore	Lat 40 54 50 Long 73 54 39	1	Ebb	16	68	5.14	77
2087	3.25	" " " " " "	Lat 40 54 50 Long 73 54 39	20	Ebb	16	68	5.14	79
2088	3.27	" " " " " "	Lat 40 54 50 Long 73 54 39	40	Ebb	16	68	5.14	79
2089	3.30	Half way across	Lat 40 54 50 Long 73 55 15	1	Ebb	16	68	5.18	78
2090	3.32	" " "	Lat 40 54 50 Long 73 55 15	20	Ebb	16	68	5.18	80
2091	3.34	" " "	Lat 40 54 50 Long 73 55 15	38	Ebb	16	68	5.18	80
2092	3.36	3/4way across from east shore	Lat 40 54 50 Long 73 55 30	1	Ebb	16	70	5.26	79
2093	3.40	" " " " " "	Lat 40 54 50 Long 73 55 30	10	Ebb	16	68	5.26	81
2094	3.42	" " " " " "	Lat 40 54 50 Long 73 55 30	20	Ebb	16	68	5.26	81
2095	3.46	800 feet off west shore	Lat 40 54 50 Long 73 55 42	1	Ebb	16	70	5.36	80
2096	3.48	" " " " "	Lat 40 54 50 Long 73 55 42	10	Ebb	16	68	5.36	83
2097	3.50	" " " " "	Lat 40 54 50 Long 73 55 42	18	Ebb	16	68	5.36	83

PEOPLE OF STATE OF NEW YORK vs. STATE OF NEW JERSEY.

Dissolved Oxygen. Upper New York Bay - vicinity of Robbins Reef light. October 16, 1911.

Low water occurred at Governors Island at 9.06 a.m. High water at 3.09 p.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent satura-tion
		Approximate	Exact ° ' "						
2038	9.20	1/2 mile N. E. Robbins Reef light	Lat 40 39 44 Long 74 03 29	1	Ebb	16	36	3.96	64
2039	9.22	" " " "	Lat 40 39 44 Long 74 03 29	25	Ebb	16.8	32	3.96	63
2040	9.25	" " " "	Lat 40 39 44 Long 74 03 29	45	Ebb	16.8	32	3.96	63
2041	9.36	1/2 mile E.S.E. Robbins Reef light	Lat 40 39 16 Long 74 03 25	1	Ebb	16	36	3.96	64
2042	9.37	" " " "	Lat 40 39 16 Long 74 03 25	20	Ebb	16.8	32	4.12	66
2043	9.40	" " " "	Lat 40 39 16 Long 74 03 25	40	Ebb	16.8	32	4.12	66
2044	9.50	1/2 mile S. Robbins Reef light	Lat 40 38 49 Long 74 03 48	1	Ebb	16	36	4.03	65
2045	9.52	" " " "	Lat 40 38 49 Long 74 03 48	25	Ebb	16.8	32	4.03	67
2046	9.55	" " " "	Lat 40 38 49 Long 74 03 48	50	Ebb	16.8	32	4.03	67

Dissolved Oxygen. Upper New York Bay - vicinity of Robbins Reef light. October 16, 1911.

Low water occurred at Governors Island at 9.06 a.m. High water at 3.09 p.m. Ebb currents ended 11.45 a.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
2047	11.20	1/2 mile N. E. Robbins Reef light	Lat 40 39 44 Long 74 03 29	1	End of Ebb	16	44	4.10	65
2048	11.22	" " " " "	Lat 40 39 44 Long 74 03 29	25	Flood	16.5	32	3.96	65
2049	11.25	" " " " "	Lat 40 39 44 Long 74 03 29	45	Flood	16.5	32	3.96	65
2050	11.35	1/2 mile E.S.E. Robbins Reef light	Lat 40 39 16 Long 74 03 25	1	End of Ebb	16	44	4.12	66
2051	11.37	" " " "	Lat 40 39 16 Long 74 03 25	20	Flood	16.5	32	3.99	66
2052	11.40	" " " "	Lat 40 39 16 Long 74 03 25	40	Flood	16.5	32	3.98	66
2053	11.50	1/2 mile S. Robbins Reef light	Lat 40 38 49 Long 74 03 48	1	End of Ebb	16	44	4.17	66
2054	11.52	" " " "	Lat 40 38 49 Long 74 03 48	25	Flood	16.5	32	4.03	67
2055	11.55	" " " "	Lat 40 38 49 Long 74 03 48	50	Flood	16.5	32	4.03	67
2056	1.20	1/2 mile N.E. Robbins Reef light	Lat 40 39 44 Long 74 03 29	1	Flood	16	40	4.24	68
2057	1.22	" " " " "	Lat 40 39 44 Long 74 03 29	25	Flood	16	28	4.65	77
2058	1.25	" " " " "	Lat 40 39 44 Long 74 03 29	45	Flood	16	28	4.65	77
2059	1.35	1/2 mile E.S.E. Robbins Reef light	Lat 40 39 16 Long 74 03 25	1	Flood	16	42	4.12	67
2060	1.37	" " " "	Lat 40 39 16 Long 74 03 25	20	Flood	16	28	4.40	73
2061	1.40	" " " "	Lat 40 39 16 Long 74 03 25	40	Flood	16	28	4.40	73

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reeflight- Oct.16.1911.

Low water occurred at Governors Island at 9.06 a.m. High water at 3.09 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent saturation
2062	1.50	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	1	Flood	16	36	4.31	71
2063	1.52	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	25	Flood	16	24	4.58	76
2064	1.55	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	50	Flood	16	24	4.58	76
2065	3.20	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	1	Flood	16	32	4.65	77
2066	3.22	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	25	Flood	16	22	4.65	77
2067	3.25	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	45	Flood	16	22	4.65	77
2068	3.35	1/2 mile E.S.E. Robbins Reeflight	Lat 40 39 16 Long 74 03 25	1	Flood	16	32	4.55	75
2069	3.37	1/2 mile E.S.E. Robbins Reeflight	Lat 40 39 16 Long 74 03 25	20	Flood	16	22	4.55	76
2070	3.40	1/2 mile E.S.E. Robbins Reeflight	Lat 40 39 16 Long 74 03 25	40	Flood	16	22	4.55	76
2071	3.50	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	1	Flood	16	28	4.53	76
2072	3.52	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	25	Flood	16	20	4.58	76
2073	3.55	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	50	Flood	16	20	4.58	76
2074	5.10	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	1	Flood	16	30	4.65	77
2075	5.12	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	25	Flood	16	20	4.65	79
2076	5.14	1/2 mile N.E. Robbins Reef-light	Lat 40 39 44 Long 74 03 29	45	Flood	16	20	4.65	79

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reeflight. Oct.16,1911.

Low water occurred at Governors Island at 9.06 a.m. High water at 3.09 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal currents	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2077	5.18	1/2 mile E.S.E. Robbins Reef-light	Lat 40 39 16 Long 74 03 25	1	Flood	16	30	4.55	75
2078	5.20	1/2 mile E.S.E. Robbins Reef-light	Lat 40 39 16 Long 74 03 25	20	Flood	16	20	4.68	79
2079	5.22	1/2 mile E.S.E. Robbins Reef-light	Lat 40 39 16 Long 74 03 25	40	Flood	16	20	4.68	79
2080	5.26	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	1	Flood	16	30	4.58	76
2081	5.28	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	25	Flood	16	20	4.58	76
2082	5.30	1/2 mile S. Robbins Reef-light	Lat 40 38 49 Long 74 03 48	50	Flood	16	20	4.58	76

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reef. Oct. 23, 1911.

High water occurred at Governors Island at 8.37 a.m. Low water at 3.10 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal currents	Temp. water Deg. C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2083	9.30	500 feet east of Buoy 62-1 mile north of Robbins Reef light	Lat 40 40 12 Long 74 03 10	1	Flood	16	62	4.78	75
2084	9.32	" "	Lat 40 40 12 Long 74 03 10	28	Flood	16	34	4.65	75
2085	9.35	" "	Lat 40 40 12 Long 74 03 10	50	Flood	16	32	4.65	76
2086	9.45	1 mile E.S.E. Robbins Reef light-Line from light to 64 St.Brooklyn-and from Liberty Island to Fort Wadsworth	Lat 40 39 05 Long 74 02 53	1	Flood	16	62	4.72	74
2087	9.47	" "	Lat 40 39 05 Long 74 02 53	15	Flood	16	34	4.72	76
2088	9.50	" "	Lat 40 39 05 Long 74 02 53	30	Flood	16	32	4.72	77
2089	10.00	1 mile S.S.E. Robbins Reef light-Midway between 2 spar buoys off Tompkinsville,S.I.	Lat 40 38 33 Long 74 03 42	1	Flood	16	44	4.83	77
2090	10.02	" "	Lat 40 38 33 Long 74 03 42	28	Flood	16	32	4.83	79
2091	10.05	" "	Lat 40 38 33 Long 74 03 42	50	Flood	16	30	4.83	79
2092	10.15	1/4 mile S.of E. of Robbins Reef light-1/4 mile N.E. of Robbins Reef bell buoy	Lat 40 39 26 Long 74 03 37	1	Flood	16	46	4.92	79
2093	10.17	" "	Lat 40 39 26 Long 74 03 37	30	Flood	16	34	4.92	81
2094	10.20	" "	Lat 40 39 26 Long 74 03 37	50	Flood	16	32	4.92	81
2095	10.44	Narrows-Midway between Forts	Lat 40 36 25 Long 74 02 48	1	Flood	16	42	5.07	81
2096	10.47	" " " "	Lat 40 36 25 Long 74 02 48	40	Flood	16	32	5.07	83
2097	10.50	" " " "	Lat 40 36 25 Long 74 02 48	80	Flood	16	30	5.07	83

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reef. Oct.23, 1911.

Ebb currents began about 11.18 a.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Location of Samples: Exact ° ' "	Feet below surface	Tidal currents	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2098	12.30	800 feet east of Buoy G2	Lat 40 40 12 Long 74 03 10	1	Ebb	16	82	4.10	68
2099	12.32	" " " " " "	Lat 40 40 12 Long 74 03 10	25	Ebb	16	36	4.10	66
2100	12.36	" " " " " "	Lat 40 40 12 Long 74 03 10	50	Ebb	16	38	4.10	66
2101	12.48	1 mile E.S.E. Robbins Reef	Lat 40 39 08 Long 74 02 53	1	Ebb	16	84	4.31	68
2102	12.47	" " " " " "	Lat 40 39 08 Long 74 02 53	15	Ebb	16	36	4.58	74
2103	12.50	" " " " " "	Lat 40 39 08 Long 74 02 53	30	Ebb	16	36	4.58	74
2104	1.00	1 mile S.S.E. Robbins Reef	Lat 40 38 33 Long 74 03 42	1	Ebb	16	84	4.68	74
2105	1.02	" " " " " "	Lat 40 38 33 Long 74 03 42	25	Ebb	16	46	4.80	72
2106	1.05	" " " " " "	Lat 40 38 33 Long 74 03 42	50	Ebb	16	46	4.88	72
2107	1.15	1/4 mile S.of E.of Robbins Reef	Lat 40 39 26 Long 74 03 37	1	Ebb	16	66	4.78	78
2108	1.17	" " "	Lat 40 39 26 Long 74 03 37	30	Ebb	16	40	4.78	76
2109	1.20	" " "	Lat 40 39 26 Long 74 03 37	50	Ebb	16	40	4.78	76
2110	1.45	Narrows-Midway between Forts	Lat 40 36 28 Long 74 02 48	1	Ebb	16	84	4.63	73
2111	1.47	" " " "	Lat 40 36 28 Long 74 02 48	40	Ebb	16	42	4.63	74
2112	1.50	" " " "	Lat 40 36 28 Long 74 02 48	80	Ebb	16	42	4.63	74

Dissolved oxygen. Upper New York Bay - vicinity of Robbins Reef. October 28, 1911.
(Continued.)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg. C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2113	3.30	800 feet E. of Buoy 28	Lat 40 40 12 Long 74 03 10	1	Ebb	16	66	4.81	69
2114	3.36	" " " " " "	Lat 40 40 18 Long 74 03 10	28	Ebb	16	52	4.39	70
2115	3.38	" " " " " "	Lat 40 40 12 Long 74 03 10	50	Ebb	16	68	4.50	70
2116	3.48	1 mile E.S.E. Robbins Reef	Lat 40 39 08 Long 74 02 58	1	Ebb	16	74	4.80	69
2117	3.47	" " " " "	Lat 40 39 08 Long 74 02 58	18	Ebb	16	80	4.44	69
2118	3.50	" " " " "	Lat 40 39 06 Long 74 02 58	30	Ebb	16	58	4.44	70
2119	4.00	1 mile S.S.E. Robbins Reef	Lat 40 39 58 Long 74 03 48	1	Ebb	16	68	4.40	70
2120	4.02	" " " " "	Lat 40 39 53 Long 74 03 48	28	Ebb	16	58	4.26	68
2121	4.05	" " " " "	Lat 40 39 35 Long 74 03 48	80	Ebb	16	52	4.26	68
2122	4.18	1/4 mile S. of S. of Robbins Reef	Lat 40 39 26 Long 74 03 37	1	Ebb	16	64	4.34	67
2123	4.17	" " " " "	Lat 40 39 26 Long 74 03 37	30	Ebb	16	52	4.34	69
2124	4.20	" " " " "	Lat 40 39 26 Long 74 03 37	80	Ebb	16	50	4.34	69
2125	4.48	Narrows-midway between forts	Lat 40 36 38 Long 74 02 49	1	Ebb	16	64	4.98	76
2126	4.47	" " " "	Lat 40 36 25 Long 74 02 49	40	Ebb	16	50	4.92	79
2127	4.50	" " " "	Lat 40 36 25 Long 74 02 49	80	Ebb	16	50	4.92	79

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reef. Oct. 24, 1911.

High water occurred at Governors Island at 9.18 a.m. Low water at 3.58 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current-route	Temp. water Deg.C	Per-cent land water	Oxygen D.O. per litre	Oxygen Percent saturation
2128	9.45	1/4 mile S.of E.of Robbins Reef light	Lat 40 39 26	1	Flood	18.8	52	4.68	78
			Long 74 03 37						
2129	9.48	" " "	Lat 40 39 26	30	Flood	18.8	44	4.86	68
			Long 74 03 37						
2130	9.51	" " "	Lat 40 39 26	50	Flood	18.8	44	4.50	68
			Long 74 03 37						
2131	10.00	1/4 mile S.E. Robbins Reef light	Lat 40 39 19	1	Flood	18.8	52	4.72	72
			Long 74 03 48						
2132	10.03	" " "	Lat 40 39 19	30	Flood	18.8	44	4.44	69
			Long 74 03 48						
2133	10.06	" " "	Lat 40 39 19	40	Flood	18.8	42	4.44	70
			Long 74 03 48						
2134	10.16	1/4 mile S. Robbins Reef light	Lat 40 39 13	1	Flood	18.8	46	4.83	75
			Long 74 03 54						
2135	10.19	" " "	Lat 40 39 13	10	Flood	18.8	42	4.55	72
			Long 74 03 54						
2136	10.21	" " "	Lat 40 39 13	20	Flood	18.8	38	4.55	72
			Long 74 03 54						
2137	10.30	Bear Spar Buoy A (nearest Baxter Ledge)off Tompkinsville	Lat 40 38 44	1	Flood	18.8	58	4.98	76
			Long 74 03 42						
2138	10.33	" " "	Lat 40 38 44	25	Flood	18.8	36	4.98	79
			Long 74 03 42						
2139	10.36	" " "	Lat 40 38 44	30	Flood	18.8	34	4.98	79
			Long 74 03 42						
2140	11.00	Narrows-Midway between forts	Lat 40 36 25	1	Flood	18.8	42	5.22	83
			Long 74 02 48						
2141	11.03	" " " "	Lat 40 36 25	40	Flood	18.8	30	5.07	82
			Long 74 02 48						
2142	11.06	" " " "	Lat 40 36 25	80	Flood	18.8	30	5.07	82
			Long 74 02 48						

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2524

Dissolved Oxygen. Upper New York Bay-vicinity of Robbins Reef. Oct. 24. 1911.

Ebb currents began about 11.45 a.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact Lat o ' "	Exact Long o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2143	12.45	½ mile S of E. of Robbins Reef	40 39 26	74 03 37	1	Ebb	16	56	4.94	77
2144	12.48	" "	40 39 26	74 03 37	30	Ebb	16	40	4.94	79
2145	12.51	" "	40 39 26	74 03 37	60	Ebb	16	40	4.94	79
2146	1.00	" S.E. of Robbins Reef	40 39 19	74 03 42	1	Ebb	16	56	5.00	78
2147	1.03	" "	40 39 19	74 03 42	20	Ebb	16	40	5.00	80
2148	1.06	" "	40 39 19	74 03 42	40	Ebb	16	40	5.00	80
2149	1.15	" S. of Robbins Reef	40 39 13	74 03 54	1	Ebb	16	56	5.11	80
2150	1.18	" " "	40 39 13	74 03 54	10	Ebb	16	46	5.11	82
2151	1.21	" " "	40 39 13	74 03 54	20	Ebb	16	42	5.11	82
2152	1.30	Near spar buoy A nearest Baxter Ledge	40 38 44	74 03 42	1	Ebb	16	54	5.22	82
2153	1.33	" " "	40 38 44	74 03 42	25	Ebb	16	44	5.22	83
2154	1.36	" " "	40 38 44	74 03 42	50	Ebb	16	42	5.22	83
2155	2.00	Narrows midway between forts	40 36 25	74 03 48	1	Ebb	16	54	5.22	82
2156	2.03	" " "	40 36 25	74 02 48	40	Ebb	16	40	5.22	83
2157	2.06	" " "	40 36 25	74 02 48	80	Ebb	16	40	5.22	83

Dissolved Oxygen. Upper New York Bay - vicinity of Robbins Reef. October 24. 1911.
(Continued.)

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent satura-tion
2158	3.45	1/4 mile S. of E. of Robbins Reef	Lat 40 39 26 Long 74 03 37	1	Ebb	15.5	64	5.06	77
2159	3.47	" " " " " "	Lat 40 39 26 Long 74 03 37	30	Ebb	15.5	52	5.06	78
2160	3.50	" " " " " "	Lat 40 39 26 Long 74 03 37	60	Ebb	15.5	52	5.06	78
2161	4.00	1/4 mile S. E. of Robbins Reef	Lat 40 39 19 Long 74 03 42	1	Ebb	15.5	64	5.14	78
2162	4.02	" " " " "	Lat 40 39 19 Long 74 03 42	20	Ebb	15.5	52	5.14	80
2163	4.05	" " " " "	Lat 40 39 19 Long 74 03 42	40	Ebb	15.5	52	5.14	80
2164	4.15	1/4 mile S. of Robbins Reef	Lat 40 39 13 Long 74 03 54	1	Ebb	15.5	68	5.26	79
2165	4.17	" " " " " "	Lat 40 39 13 Long 74 03 54	10	Ebb	15.5	52	5.26	81
2166	4.20	" " " " " "	Lat 40 39 13 Long 74 03 54	20	Ebb	15.5	52	5.26	81
2167	4.30	Near spar bucy A nearest Baxter Ledge	Lat 40 38 44 Long 74 03 42	1	Ebb	15.5	68	5.36	80
2168	4.32	" " " "	Lat 40 38 44 Long 74 03 42	25	Ebb	15.5	52	5.36	83
2169	4.35	" " " "	Lat 40 38 44 Long 74 03 42	50	Ebb	15.5	52	5.36	83
2170	4.50	Narrows midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	15.5	60	5.52	84
2171	4.52	" " " "	Lat 40 36 25 Long 74 02 48	40	Ebb	15.5	52	5.52	86
2172	4.55	" " " "	Lat 40 36 25 Long 74 02 48	80	Ebb	15.5	52	5.52	86

Dissolved Oxygen.

East River Cross-section. Throgs Neck to Willets Point. October 25, 1911.

High water at Governors Island at 9.52 a.m. Low water at Hell Gate at 5.30 a.m.

High water at Hell Gate at 11.42 a.m. Low water at 6.20 p.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
		Approximate	Exact ° ' "						
2173	7.30	1/4 way across from Throgs Neck	Lat 40 48 08 Long 73 47 42	1	Ebb	15	26	4.36	71
2174	7.32	" " " " " "	Lat 40 48 08 Long 73 47 42	30	Ebb	14.5	26	4.94	79
2175	7.36	" " " " " "	Lat 40 48 08 Long 73 47 42	60	Ebb	14.5	26	4.94	79
2176	7.42	Halfway across	Lat 40 48 00 Long 74 47 13	1	Ebb	15	26	4.44	72
2177	7.44	" "	Lat 40 48 00 Long 73 47 13	40	Ebb	14.5	26	5.00	80
2178	7.47	" "	Lat 40 48 00 Long 73 47 13	80	Ebb	14.5	26	5.00	80
2179	7.55	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Ebb	15	26	4.48	73
2180	7.57	" " " " " "	Lat 40 47 54 Long 73 47 05	35	Ebb	14.5	26	5.04	80
2181	8.00	" " " " " "	Lat 40 47 54 Long 73 47 05	70	Ebb	14.5	26	5.04	80
2182	9.30	1/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Flood	15	24	4.94	79
2183	9.32	" " " " " "	Lat 40 47 54 Long 73 47 05	30	Flood	15	22	5.33	87
2184	9.35	" " " " " "	Lat 40 47 54 Long 73 47 05	60	Flood	15	22	5.35	87
2185	9.42	Halfway across	Lat 40 47 54 Long 73 47 05	1	Flood	15	24	4.87	78

Ex. 94. P. 181

Dissolved Oxygen.

East River Cross-section. Throgs Neck to Willets Point. (Continued.) October 25, 1911.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2186	9.44	Halfway across	Lat 40 47 54 Long 73 47 05	40	Flood	15	22	5.42	89
2187	9.47	" "	Lat 40 47 54 Long 73 47 05	80	Flood	15	22	5.42	89
2188	9.55	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Flood	15	24	4.90	78
2189	9.57	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	35	Flood	15	24	5.46	90
2190	10.00	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	70	Flood	15	24	5.46	90
2191	11.30	1/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Flood	16	24	5.33	88
2192	11.32	" " " " " "	Lat 40 47 54 Long 73 47 05	30	Flood	16	24	5.33	88
2193	11.36	" " " " " "	Lat 40 47 54 Long 73 47 05	60	Flood	16	24	5.33	88
2194	11.42	Halfway across	Lat 40 47 54 Long 73 47 05	1	Flood	16	24	5.42	89
2195	11.44	" "	Lat 40 47 54 Long 73 47 05	40	Flood	16	24	5.42	89
2196	11.47	" "	Lat 40 47 54 Long 73 47 05	80	Flood	16	24	5.42	89
2197	11.55	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Flood	16	24	5.46	90
2198	11.57	" " " " " "	Lat 40 47 54 Long 73 47 05	35	Flood	16	24	5.46	90
2199	12.00	" " " " " "	Lat 40 47 54 Long 73 47 05	70	Flood	16	24	5.46	90
2200	1.30	1/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Ebb	16.6	24	5.33	87

Dissolved Oxygen.

East River Cross Cross-section. Throgs Neck to Willets Point. (Continued.) October 25, 1911.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2201	1.32	1/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	30	Flood	15.0	24	5.60	92
2202	1.35	" " " " " "	Lat 40 47 54 Long 73 47 05	60	Flood	15	24	5.60	92
2203	1.42	Halfway across	Lat 40 47 54 Long 73 47 05	1	Flood	15.5	24	5.42	89
2204	1.44	" "	Lat 40 47 54 Long 73 47 05	40	Flood	15	24	5.69	93
2205	1.47	" "	Lat 40 47 54 Long 73 47 05	80	Flood	15	24	5.69	93
2206	1.55	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Flood	15.5	24	5.46	90
2207	1.57	" " " " " "	Lat 40 47 54 Long 73 47 05	35	Flood	15	24	5.74	94
2208	2.00	" " " " " "	Lat 40 47 54 Long 73 47 05	70	Flood	15	24	5.74	94
2209	3.30	1/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Ebb	15.5	24	5.19	85
2210	3.32	" " " " " "	Lat 40 47 54 Long 73 47 05	30	Ebb	15.5	24	5.19	85
2211	3.35	" " " " " "	Lat 40 47 54 Long 73 47 05	60	Ebb	15.5	24	5.19	85
2212	3.42	Halfway across	Lat 40 47 54 Long 73 47 05	1	Ebb	15.5	24	5.28	87
2213	3.45	" "	Lat 40 47 54 Long 73 47 05	40	Ebb	15.5	24	5.28	87
2214	3.47	" "	Lat 40 47 54 Long 73 47 05	80	Ebb	15.5	24	5.28	87
2215	3.58	3/4 way across from Throgs Neck	Lat 40 47 54 Long 73 47 05	1	Ebb	15.5	24	5.32	87

Dissolved Oxygen.

East River Cross-section. Throgs Neck to Willets Point. (Continued.) October 25, 1911.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent atura-tion
2216	3.57	3/4 way across from Throgs Neck	Lat 40 47 54	56	Ebb	15.5	24	5.32	87
			Long 73 47 08						
2217	4.00	" " " " " "	Lat 40 47 54	10	Ebb	15.5	24	6.32	87
			Long 73 47 08						
2218	8.00	1/4 " " " " "	Lat 40 47 54	1	Ebb	15.5	24	4.68	76
			Long 73 47 08						
2219	8.02	" " " " " "	Lat 40 47 54	30	Ebb	15.5	24	5.19	85
			Long 73 47 08						
2220	8.06	" " " " " "	Lat 40 47 54	60	Ebb	15.5	24	5.19	85
			Long 73 47 08						
2221	8.12	halfway across	Lat 40 47 54	1	Ebb	15.5	24	4.72	77
			Long 73 47 08						
2222	8.14	" "	Lat 40 47 54	40	Ebb	15.5	24	5.28	87
			Long 73 47 08						
2223	8.17	" "	Lat 40 47 54	80	Ebb	15.5	24	5.28	87
			Long 73 47 08						
2224	8.25	3/4 way across from Throgs Neck	Lat 40 47 54	1	Ebb	15.5	24	4.76	78
			Long 73 47 08						
2225	8.27	" " " " " "	Lat 40 47 54	35	Ebb	15.5	24	5.32	87
			Long 73 47 08						
2226	8.30	" " " " " "	Lat 40 47 54	70	Ebb	15.5	24	4.32	87
			Long 73 47 08						

Dissolved Oxygen. Upper New York Bay- Course from mouth of Hudson river to Narrows. October 26, 1911.

High Water at Governors Island at 10.38 a.m. Low Water at 8.05 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2227	10.20	Hudson river-midstream off Pier A	Lat 40 42 19 Long 74 01 54	1	Flood	18.8	74	5.19	76
2228	10.28	" "	Lat 40 42 19 Long 74 01 54	20	"	18	82	4.78	74
2229	10.28	" "	Lat 40 42 19 Long 74 01 54	40	"	18	82	4.78	74
2230	10.40	800 ft. N.of Red spar buoy 2 off Ellis Island	Lat 40 41 51 Long 74 02 03	1	"	18.8	70	5.38	79
2231	10.42	" "	Lat 40 41 51 Long 74 02 03	18	"	18	82	5.38	81
2232	10.45	" "	Lat 40 41 51 Long 74 02 03	38	"	18	46	5.38	68
2233	11.00	800 ft.N.of Gas buoy 2 off Liberty Island	Lat 40 41 10 Long 74 02 30	1	"	18.8	68	5.11	76
2234	11.02	" "	Lat 40 41 10 Long 74 02 30	20	"	18	84	5.11	77
2235	11.05	" "	Lat 40 41 10 Long 74 02 30	40	"	18	84	5.11	77
2236	11.20	800 ft.N.of buoy 6 E off entrance to N.R.R.Ferry	Lat 40 40 18 Long 74 03 13	1	"	18.8	64	5.81	84
2237	11.22	" "	Lat 40 40 18 Long 74 03 13	18	"	18	48	5.82	80
2238	11.25	" "	Lat 40 40 18 Long 74 03 13	30	"	18	48	5.82	80
2239	11.40	½ mile S.of N.of Robbins Reef light	Lat 40 39 26 Long 74 03 37	1	"	18.8	68	5.39	77
2240	11.42	" "	Lat 40 39 26 Long 74 03 37	30	"	18	44	5.19	80
2241	11.45	" "	Lat 40 39 26 Long 74 03 37	60	"	18	44	5.19	80

Dissolved Oxygen. Upper New York bay- Course from mouth of Hudson river to Narrows. October 26, 1911

Continued.

High Water at Governors Island at 10.32 a.m. Low Water at 5.25 p.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2242	12.00	200 ft.W.of Bell buoy 12ft off Owl Head	Lat 40 38 22 Long 74 03 17	1	Flood	15.5	60	5.00	77
2243	12.02	" "	Lat 40 38 22 Long 74 03 17	15	"	15	40	5.00	78
2244	12.05	" "	Lat 40 38 22 Long 74 03 17	30	"	15	40	5.00	78
2245	12.25	Narrows-mid way between forts	Lat 40 36 25 Long 72 04 28	1	"	15.5	48	5.26	81
2246	12.27	" "	Lat 40 36 25 Long 74 02 48	40	"	15	36	5.26	83
2247	12.30	" "	Lat 40 36 25 Long 74 02 48	80	"	15	36	5.26	83

Dissolved Oxygen — Upper New York bay- Course from mouth of Hudson river to Narrows. — October 26, 1911

High Water at Governors Island at 10.52 a.m. Low Water at 5.25 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact.	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2248	3.30	Narrows-midway between forts	Lat 40 36 26 Long 74 02 48	1	Ebb	16	64	5.11	77
2249	3.32	" "	Lat 40 36 25 Long 74 02 48	40	"	16	46	5.11	81
2250	3.35	" "	Lat 40 36 25 Long 74 02 48	80	"	16	46	5.11	81
2251	4.00	200 ft.W.of Bell buoy 12½ off Owl Head	Lat 40 36 25 Long 74 02 48	1	"	16	64	4.98	75
2252	4.02	" "	Lat 40 36 25 Long 74 02 48	15	"	16	44	5.28	84
2253	4.05	" "	Lat 40 36 25 Long 74 02 48	30	"	16	44	5.28	84
2254	4.15	½ mile S.of E.of Robbins Reef light	Lat 40 39 26 Long 74 03 37	1	"	16	64	4.78	73
2255	4.17	" "	Lat 40 39 26 Long 74 03 37	30	"	16	50	4.78	75
2256	4.20	" "	Lat 40 39 26 Long 74 03 37	60	"	16	50	4.78	75
2257	4.30	200 ft.E.of buoy G2	Lat 40 39 26 Long 74 03 37	1	"	16	60	4.92	76
2258	4.32	" "	Lat 40 39 26 Long 74 03 37	15	"	16	52	4.92	77
2259	4.35	" "	Lat 40 39 26 Long 74 03 37	30	"	16	52	4.92	77
2260	4.45	500 ft.E of Gas buoy 2 off Liberty Island	Lat 40 39 26 Long 74 03 37	1	"	16	70	5.39	81
2261	4.47	" "	Lat 40 39 26 Long 74 03 37	20	"	16	66	5.11	80
2262	4.50	" "	Lat 40 39 26 Long 74 03 37	40	"	16	66	5.11	80

Dissolved Oxygen — Upper New York bay-Course from mouth of Hudson river to Narrows. — October 26, 1911

Continued

High Water at Governors Island at 10.32 a.m. — Low Water at 5.25 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2263	5.00	200 ft.E.of Red spar buoy 2, off Ellis Island	Lat 40 41 51 Long 74 02 03	1	Ebb	16	76	5.28	79
2264	5.02	" "	Lat 40 41 51 Long 74 02 03	15	"	16	68	5.00	75
2265	5.04	" "	Lat 40 41 51 Long 74 02 03	25	"	16	66	5.00	78
2266	5.08	Hudson river-midstream off Pier A	Lat 40 42 19 Long 74 01 34	1	"	16	78	5.19	76
2267	5.10	" "	Lat 40 42 19 Long 74 01 34	20	"	16	66	4.94	77
2268	5.12	" "	Lat 40 42 19 Long 74 01 34	40	"	16	54	4.94	77

Ex. 94. P. 188

Dissolved Oxygen — Hudson River — October 27, 1911

High Water at Governors Island at 11.10 a.m. — Low Water at 6.18 p.m.

Sample No.	Hour a.m.	Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2269	11.15	Hudson River-midstream off Pier A	Lat 40 42 19 Long 70 01 34	1	Flood	15	76	5.42	61
2270	11.17	" "	Lat 40 42 19 Long 70 01 34	20	"	15	40	5.28	64
2271	11.20	" "	Lat 40 42 19 Long 70 01 34	40	"	15	36	5.28	65
2272	2.30	Hudson River-midstream off Spuyten Duyvil	Lat 40 52 50 Long 73 56 04	1	"	15	68	5.03	62
2273	2.32	" "	Lat 40 52 50 Long 73 56 04	15	"	15	68	5.00	74
2274	2.35	" "	Lat 40 52 50 Long 73 56 04	30	"	15	60	5.00	75

Dissolved Oxygen — Slips, etc. — Oct. 30, 1911.

High water occurred at Governors Island at 1.38 p.m. Low water at 7.52 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2275	10.30	1000' off Morse Dry Docks bet. 55 and 57 St. Bklyn.	Lat 40 39 05 Long 74 01 53	1	Flood	15	80	4.17	64
2276	10.35	" " "	Lat 40 39 05 Long 74 01 53	30	Flood	15	80	4.17	64
2277	11.30	2nd slip east of De Graw St. middle of Slip	Lat 40 41 16 Long 74 00 24	1	Flood	15	46	3.06	47
2278	11.35	" "	Lat 40 41 16 Long 74 00 24	20	Flood	15	46	3.33	52
2279	1.00	Wall about canal near Market	Lat 40 42 12 Long 73 58 08	1	Flood	15	80	1.67	30
2280	1.05	" "	Lat 40 42 12 Long 73 58 08	20	Flood	15	80	1.67	30
2281	1.45	Slip No. of foot E.24 St. New York, middle of slip	Lat 40 44 09 Long 73 58 27	1	Flood	15	46	3.06	47
2282	1.50	" "	Lat 40 44 09 Long 73 58 27	20	Flood	15	46	3.06	47
2283	2.30	Slip foot Broadway, Astoria Outer end of slip.	Lat 40 46 07 Long 73 56 16	1	Flood	15	42	2.78	43
2284	2.35	" "	Lat 40 46 07 Long 73 56 16	10	Flood	15	42	2.78	43

Dissolved Oxygen. Slips, etc. Oct. 20, 1911.

High water occurred at Hell Gate at 3.20 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2205	3.00	Slip, foot E. 209 St. Harlem River	Lat 40 47 24 Long 73 56 11	1	Flood	18	40	2.80	39
2206	3.25	" "	Lat 40 47 24 Long 73 56 11	60	Flood	18	40	2.80	39

Rm. 94. P. 191

Dissolved Oxygen. The Narrows - Deep hole outside Port Lafayette. Nov. 1, 1911.

Low water occurred at Governors Island at 9.52 a.m. High water at 3.50 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2287	1.00	The Narrows, line between red spar buoy 12A and black can buoy 13-1/3 way across from buoy 12A South of Ft. Hamilton.	Lat 40 35 57 Long 74 02 18	1	Ebb	14.8	42	8.00	78
2288	1.08	" " "	Lat 40 35 57 Long 74 02 18	60	Flood	15	30	8.42	87
2289	1.10	" " "	Lat 40 35 57 Long 74 02 18	120	Flood	15	28	8.42	87
2290	3.30	The Narrows, deep hole, same as above	Lat 40 36 57 Long 74 02 18	1	Flood	14.8	34	8.42	88
2291	3.38	" " "	Lat 40 36 57 Long 74 02 18	60	Flood	15	28	8.84	90
2292	3.40	" " "	Lat 40 35 57 Long 74 02 18	120	Flood	15	24	8.84	90

Ex. 94. P. 192

Dissolved Oxygen. Harlem River, slip foot East 109th St. Nov. 2. 1911.

Low water occurred at Governors Island at 10.42 a.m. High water at 4.25 p.m.

Low water occurred at Hell Gate at 12.40 p.m. High water at 6.15 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2293	12.30	Slip foot E. 109 St.	Lat 40 47 24 Long 73 56 11	1	Ebb	14	32	2.22	35
2294	12.35	" " " " "	Lat 40 47 24 Long 73 56 11	15	Ebb	14.5	32	2.22	35
2295	1.30	" " " " "	Lat 40 47 24 Long 73 56 11	1	Flood	14	30	2.22	35
2296	1.35	" " " " "	Lat 40 47 24 Long 73 56 11	15	Flood	14.5	30	2.22	35
2297	2.30	" " " " "	Lat 40 47 24 Long 73 56 11	1	Flood	14	30	2.22	35
2298	2.35	" " " " "	Lat 40 47 24 Long 73 56 11	15	Flood	14	30	2.22	35
2299	4.00	" " " " "	Lat 40 47 24 Long 73 56 11	1	Flood	13.5	30	2.22	34
2300	4.05	" " " " "	Lat 40 47 24 Long 73 56 11	15	Flood	14	30	2.22	35

Dissolved Oxygen. East River, deep hole E. 134 St. and Slip E. 14 St. Nov. 3, 1911.

Low water occurred at Governors Island at 11.30 a.m. High water at 5.12 p.m.

Low water occurred at Hell Gate at 1.10 p.m. High water at 7.02 p.m.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen	
		Approximate	Exact ° ' "					C.C. per litre	Percent saturation
2301	9.30	East River 200' off E. 134 St. ferry, deep hole	Lat 40 47 56 Long 73 54 30	1	Ebb	13	24	5.11	79
2302	9.35	" "	Lat 40 47 56 Long 73 54 30	40	Ebb	12	22	5.39	84
2303	9.40	" "	Lat 40 47 56 Long 73 54 30	75	Ebb	12	22	5.39	84
2304	11.00	Slip between foot E. 13 and 14 St. New York, inner end	Lat 40 43 36 Long 73 58 24	1	Ebb	13	36	3.12	47
2305	11.05	"	Lat 40 43 36 Long 73 58 24	15	Ebb	13	36	3.12	47

Dissolved Oxygen. East River, deep hole at Old Ferry Pt. and Stepping Stones. Nov. 8, 1911.

High water occurred at Governors Island at 8.45 a.m. Low water at 3.25 p.m.

High water occurred at Hell Gate at 10.35 a.m. Low water at 5.05 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal-current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent satura-tion
		Approximate	Exact ° ' "						
2306	2.00	East River, deep hole ¼ mile E. of Old Ferry St.	Lat 40 48 18 Long 73 49 20	1	Ebb	12	24	5.46	84
2307	2.05	" " "	Lat 40 48 18 Long 73 49 20	50	Ebb	13	22	5.46	85
2308	2.10	" " "	Lat 40 48 18 Long 73 49 20	110	Ebb	13	22	5.46	85
2309	3.00	Long Is. Sound-¼ mile west of Stepping Stones light	Lat 40 49 33 Long 73 46 59	1	Ebb	12	22	5.83	90
2310	3.05	" " "	Lat 40 49 33 Long 73 46 59	50	Ebb	13	22	5.83	91
2311	3.10	" " "	Lat 40 49 33 Long 73 46 59	100	Ebb	13	22	5.83	91

Ex. 94. P. 198

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2811

Dissolved Oxygen. East River slips-DeGraw St. & vicinity. Nov. 9, 1911.

High water occurred at Governors Island at 9.30 a.m. Low water at 4.20 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent Satura-tion
2312	10.30	Slip 2 blocks east of DeGraw St. Half-way up slip.	Lat 40 41 16 Long 74 00 28	1	Flood	13	30	2.78	42
2313	10.33	" "	Lat 40 41 16 Long 74 00 28	15	Flood	13	30	2.78	42
2314	11.30	Slip at De Graw St. Brklyn. outer end.	Lat 40 41 14 Long 74 00 29	1	Ebb	13	30	2.78	42
2315	11.33	" "	Lat 40 41 14 Long 74 00 29	15	Ebb	13	30	2.78	42

Ex. 94. P. 196

STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3642

Dissolved Oxygen. Hudson River, Fort Washington Point. Nov. 10. 1911.

High water occurred at Governors Island at 10.25 a.m. Low water at 5.15 p.m.

High water at Hell Gate at 12.50 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2316	12.10	500' off Ft. Washington Pt. to S.W.	Lat 40 50 55 Long 73 56 57	1	Flood	11.5	56	5.00	71
2317	12.15	" " "	Lat 40 50 55 Long 73 56 57	75	Flood	12	48	5.00	71
2318	12.25	" " "	Lat 40 50 55 Long 73 56 57	150	Flood	12	48	5.00	71

Ex. 94. P.197

Dissolved Oxygen. Newton Creek. November 13, 1911.

Low water occurred at Governors Island at 7.48 a.m. High water at 1.30 p.m.

Low water occurred at Hell Gate at 9.28 a.m. High water at 3.26 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
2319	11.00	Mouth of Creek	Lat 40 44 15 Long 73 57 45	1	Flood	11	32	5.41	80
2320	11.05	" " "	Lat 40 44 15 Long 73 57 45	30	Flood	11	32	5.41	80
2321	11.30	Vernon Av. bridge, 1st bridge	Lat 40 44 21 Long 73 57 30	1	Flood	11	32	0.84	12
2322	11.35	" " "	Lat 40 44 21 Long 73 57 30	30	Flood	11	32	0.84	12
2323	12.00	Greenpoint Av. bridge 2nd bridge	Lat 40 44 00 Long 73 56 30	1	Flood	11	32	0.29	4
2324	12.05	" " "	Lat 40 44 00 Long 73 56 30	30	Flood	11	32	0.29	4
2325	12.30	Meeker Av. bridge, 3rd bridge	Lat 40 43 40 Long 73 55 00	1	Flood	11	32	0	0
2326	12.35	" " "	Lat 40 43 40 Long 73 55 00	18	Flood	11	32	0	0

Dissolved Oxygen. Slips in Harlem River and East River. Nov. 15, 1911.

High water at Hell gate at 3.26 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg. C	Per cent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
				o	'	"					
2327	2.00	Slip S. of foot East 109 St. Harlem River	Lat	40	47	24	1	Flood	11	30	2.22	33
			Long	73	56	11						
2328	2.03	Slip S. of foot East 109 St. Harlem River	Lat	40	47	24	18	Flood	11	30	2.22	33
			Long	73	56	11						
2329	2.28	Slip S. of foot East 119 St. Harlem River	Lat	40	47	48	1	Flood	11	30	2.22	33
			Long	73	56	47						
2330	2.30	Slip S. of foot East 119 St. Harlem River	Lat	40	47	48	18	Flood	11	30	2.22	33
			Long	73	56	47						
2331	3.30	Slip at Port Morris, East river	Lat	40	48	20	1	Flood	11	30	2.78	41
			Long	73	54	07						
2332	3.36	Slip at Port Morris, East river	Lat	40	48	20	18	Flood	11	30	2.78	41
			Long	73	54	07						

5263

Dissolved Oxygen. East River at Clason Pt. and L.I.Sound at Execution Rocks. November 14, 1911.

Low water at Governors Island at 9 a.m. High water at 2.50 p.m. Low water at Hell Gate at 10.40 a.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2333	2.00	Long Island sound at Execution Rocks	Lat 40 52 30 Long 73 44 15	1	Flood	10	20	6.67	98
2334	3.30	East river, midway between Clason Pt. and College Pt.	Lat 40 48 00 Long 73 51 11	1	Flood	10.5	26	4.72	69

Ex. 94. P. 200

Dissolved Oxygen. Newark Bay. November 15, 1911.

Low water at Governors Island, at 10.05 a.m. High water at 4 p.m.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen: C.C. per litre	Oxygen: Percent saturation
2335	12.30	Newark bay, by bell buoy 2 in channel	Lat 40 40 12 Long 74 08 05	1	Ebb	8	70	5.56	70

Ex. 94. P. 201

Dissolved Oxygen. Hudson River off West 23 St. and off Mt. St. Vincent.

November 16, 1911.

Low water at Governors Island at 11.a.m. High water at 4.57 p.m.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen C.C. per litre	Oxygen Percentsaturation
		Approximate	Exact ° ' "						
2336	12.15	Hudson river off West 23 St. midstream	Lat 40 45 09 Long 74 01 00	1	Ebb	9	76	4.72	61
2337	1.45	Hudson river off Mt. St. Vincent midstream	Lat 40 54 50 Long 73 55 15	1	Ebb	8	88	6.67	81

Ex. 94. F. HOE

Dissolved Oxygen. East River, Upper New York Bay, Lower New York Bay.

November 17, 1911.

High water at Governors Island at 5.25 a.m. Low water at 11.55 a.m. Low water at Sandy Hook at 11.22 a.m. High water at 5.50 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	Oxygen C.C. per litre	Oxygen Percent saturation
			°	'	"						
2338	9.00	East river off East 23 St. midstream	Lat 40	43	86	1	Ebb	9	46	4.12	56
			Long 73	88	08						
2339	10.00	New York bay by buoy 2E in channel	Lat 40	40	12	1	Ebb	9	44	4.72	65
			Long 74	03	13						
2340	11.00	New York Lower bay by buoy A C 16 in channel	Lat 40	31	42	1	Ebb	9	34	6.88	91
			Long 74	00	34						
2341	11.30	New York Lower bay by buoy A C 2 at outer end of Ambrose Channel and of Lower bay	Lat 40	29	84	1	Ebb	9.5	24	6.81	98
			Long 73	86	10						

Ex. 94. P. 203

Dissolved Oxygen

East River off East 23 St., New York.
(Midstream)

November 20, 1911.

High water at Governors Island at 7.50 a.m. Low water at 8.10 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Oxygen. D.O. per litre	Oxygen. Percent saturation
8342	1.00	East River, midstream, off East 23 St., New York	Lat 40 44 00 Long 73 58 08	1	Ebb	9	38	4.12	57

Ex. 94. P. 204

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 95.

JAMES D. MAHER,
Commissioner.

Number of Bacteria in the Water. Upper Bay. March 23. 1909.

High water occurred at Governors Island at 9.41 a.m. The wind was northwest with a velocity of 35 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1	11.40	About 2000 feet from Constable Hook	Lat 40 39 07 Long 74 04 53	1	Ebb	3		3,180
2	11.50	" " " " " "	Lat 40 39 07 Long 74 04 53	10	Ebb	3		6,360
3	1.00	Farther east than sample 1	Lat 40 39 03 Long 74 04 20	1	Ebb	3		25,400
4	1.10	" " " " "	Lat 40 39 03 Long 74 04 20	10	Ebb	3		19,100
5	1.35	" " " " 3	Lat 40 39 06 Long 74 04 38	1	Ebb	3		15,900
6	1.45	" " " " "	Lat 40 39 06 Long 74 04 38	20	Ebb	3.4		12,700
7	2.15	About 20 feet from spar buoy A	Lat 40 38 41 Long 74 03 49	1	Ebb	3		28,600
8	2.25	" " " " " " "	Lat 40 38 41 Long 74 03 49	20	Ebb	3.2		14,100
9	2.50	About 600 feet off 71 St., Brooklyn	Lat 40 38 25 Long 74 02 10	1	Ebb	3		38,100
10	3.00	" " " " "	Lat 40 38 25 Long 74 02 10	20	Ebb	3.2		26,500
11	3.35	About 200 feet farther out than sample 9	Lat 40 38 30 Long 74 02 22	1	Ebb	3.2		36,900
12	3.40	" " " " " "	Lat 40 38 30 Long 74 02 22	20	Ebb	3.4		21,600

Complainants Exhibit No. 95.

Ex. 95. P. 1

James D. Maher
Commissioner

Number of Bacteria in the Water. Upper Bay. March 23, 1909.

High water occurred at Governors Island at 9.41 a.m. The wind was northwest with a velocity of 35 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1	11.40	About 2000 feet from Constable Hook	Lat 40 39 07 Long 74 04 53	1	Ebb	3		3,180
2	11.50	" " " " " "	Lat 40 39 07 Long 74 04 53	10	Ebb	3		6,360
3	1.00	Farther east than sample 1	Lat 40 39 03 Long 74 04 20	1	Ebb	3		25,400
4	1.10	" " " " "	Lat 40 39 03 Long 74 04 20	10	Ebb	3		19,100
5	1.35	" " " " 3	Lat 40 39 06 Long 74 04 38	1	Ebb	3		15,900
6	1.45	" " " " "	Lat 40 39 06 Long 74 04 38	20	Ebb	3.4		12,700
7	2.15	About 20 feet from spar buoy A	Lat 40 38 41 Long 74 03 49	1	Ebb	3		28,600
8	2.25	" " " " " " "	Lat 40 38 41 Long 74 03 49	20	Ebb	3.2		14,100
9	2.50	About 600 feet off 71 St., Brooklyn	Lat 40 38 25 Long 74 02 10	1	Ebb	3		38,100
10	3.00	" " " " "	Lat 40 38 25 Long 74 02 10	20	Ebb	3.2		26,500
11	3.35	About 200 feet farther out than sample 9	Lat 40 38 30 Long 74 02 22	1	Ebb	3.2		36,900
12	3.40	" " " " " sample 9	Lat 40 38 30 Long 74 02 22	20	Ebb	3.4		21,600

Number of Bacteria in the Water. Upper Bay. March 24, 1909.

High water occurred at Governors Island at 10.46 p.m. The wind was east with a velocity of 5 miles per hour at 10.30 a.m., increasing to 20 miles per hour at 2.00 p.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
13	10.30	About 200 feet east of spar buoy A	Lat 40 38 39 Long 74 03 43	1	Flood	2.8		12,700
14	10.40	" " " " " " " "	Lat 40 38 39 Long 74 03 43	20	Flood	3		25,300
15	11.00	Farther east than sample 13	Lat 40 38 35 Long 74 02 43	1	Flood	2.8		19,100
16	11.05	" " " " "	Lat 40 38 35 Long 74 02 43	20	Flood	2.8		15,300
17	11.25	" " " " 15	Lat 40 38 33 Long 74 03 25	1	Flood	2.8		8,000
18	11.30	" " " " "	Lat 40 38 33 Long 74 03 25	20	Flood	2.6		6,700
19	11.45	" " " " 17	Lat 40 38 32 Long 74 03 10	1	Flood	2.8		12,700
20	11.50	" " " " "	Lat 40 38 32 Long 74 03 10	20	Flood	2.8		9,200
21	12.00	200 feet north of spar buoy 12 1/2	Lat 40 38 23 Long 74 03 18	1	Flood	3		14,000
22	12.05	" " " " " " "	Lat 40 38 23 Long 74 03 18	20	Flood	3.2		8,700
23	12.50	" " " " " " "	Lat 40 38 23 Long 74 03 18	1	Ebb	3		33,700
24	12.55	" " " " " " "	Lat 40 38 23 Long 74 03 18	20	Ebb	3.2		14,000
25	1.30	Farther east than sample 21	Lat 40 38 18 Long 74 02 43	1	Ebb	3		28,000

Number of Bacteria in the Water. Upper Bay. March 24, 1909. (Continued.)

Sample No.	Hour p.m.	Location of Samples Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
26	1.35	Farther east than sample 21	Lat 40 38 18 Long 74 02 43	20	Ebb	3.2		16,800
27	2.15	Farther east than sample 25	Lat 40 38 35 Long 74 02 43	1	Ebb	3		19,100
28	2.20	" " " " "	Lat 40 38 35 Long 74 02 43	20	Ebb	3.2		21,600
29	2.40	" " " " 27	Lat 40 38 33 Long 74 02 33	1	Ebb	3.2		31,800
30	2.45	" " " " "	Lat 40 38 33 Long 74 02 33	20	Ebb	3.4		22,900
31	3.10	" " " " 29	Lat 40 38 22 Long 74 02 25	1	Ebb	3		33,100
32	3.15	" " " " "	Lat 40 38 22 Long 74 02 25	20	Ebb	3.2		19,100
33	3.40	800 feet off 71 St. Brooklyn	Lat 40 38 19 Long 74 02 15	1	Ebb	3		39,400
34	3.45	" " " " " "	Lat 40 38 19 Long 74 02 15	20	Ebb	3.2		26,700

Number of Bacteria in the Water. Upper Bay April 7th, 1909

Low water occurred at Governors Island at 3.25 p.m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below water	Tidal current	Temp. Water Deg.C	Percent land water	Number of Bacteria per cc
35	12.50	Liberty Is.boat pier at Battery Park	Lat 40 42 08 Long 74 01 00	surface	Fbb			6,400
36	12.52	" "	Lat 40 42 08 Long 74 01 00	1/2	Ebb			5,300
37	12.54	" "	Lat 40 42 08 Long 74 01 00	1	Ebb			5,200
38	12.56	" "	Lat 40 42 08 Long 74 01 00	2	Ebb			4,600
39	1.20	Pier at east end of Liberty Is.	Lat 40 41 21 Long 74 02 38	Surface	Ebb			8,300
40	1.22	" "	Lat 40 41 21 Long 74 02 38	1/2	Ebb			8,200
41	1.24	" "	Lat 40 41 21 Long 74 02 38	1	Ebb			8,600
42	1.26	" "	Lat 40 41 21 Long 74 02 38	2	Ebb			8,100
43	3.20	End of pier A. Hudson River	Lat 40 42 16 Long 74 01 08	Surface	Ebb			10,800
44	3.22	" "	Lat 40 42 16 Long 74 01 08	1/2	Ebb			9,800
45	3.24	" "	Lat 40 42 16 Long 74 01 08	1	Ebb			6,400
46	3.26	" "	Lat 40 42 16 Long 74 01 08	2	Ebb			4,200

Number of Bacteria in the Water. Long Island Sound. April 18, 1909.

High water occurred at Governors Island at 1.56 p.m. The wind was south with a velocity of 15 miles per hour until 9.00 a.m. From 9.00 a.m. the wind was southwest with a velocity from 50 to 60 miles per hour.

Sample No.	Hour a.m.	Location of Samples Approximate	Numerical	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
47	8.00	Greenport Harbor Buoy 3	Lat 41 06 00 Long 72 21 06	1	Ebb	10		440
48	8.00	Greenport Harbor Buoy 3	Lat 41 06 00 Long 72 21 06	20	Ebb	10		120
49	6.00	Gardiners Bay just inside Orient Point	Lat 41 09 00 Long 72 12 30	1	Ebb	10		240
50	6.00	Gardiners Bay just inside Orient Point	Lat 41 09 00 Long 72 12 30	20	Ebb	10		96
51	7.00	In Long Island Sound 1000 feet off Mulfords Point	Lat 41 10 00 Long 71 17 06	1	Ebb	10		120
52	7.00	In Long Island Sound 1000 feet off Mulfords Point	Lat 41 10 00 Long 71 17 06	20	Ebb	10		68
53	8.00	In Long Island Sound 1000 feet off Rocky Point	Lat 41 08 48 Long 72 21 30	1	Ebb	10		140
54	8.00	In Long Island Sound 1000 feet off Rocky Point	Lat 41 08 48 Long 72 21 30	20	Ebb	10		80
55	9.00	In Long Island Sound 1000 feet off Hortons Point	Lat 41 08 36 Long 72 27 10	1	Ebb	12		180
56	9.00	In Long Island Sound 1000 feet off Hortons Point	Lat 41 08 36 Long 72 27 10	20	Ebb	12		64
57	10.00	In Long Island Sound 1/2 mile off Duck Pond Point	Lat 41 08 48 Long 72 31 30	1	Flood	12		180
58	10.00	In Long Island Sound 1/2 mile off Duck Pond Point	Lat 41 08 48 Long 72 31 30	20	Flood	12		68

Number of Bacteria in the Water. Long Island Sound. April 13, 1909. (Continued.)

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
59	11.00	In Long Island Sound 1/2 mile off Jacobs Landing	Lat 41 00 00 Long 72 37 00	1	Flood	12		280
60	11.00	" " " "	Lat 41 00 00 Long 72 37 00	20	Flood	12		104
61	12.00	In Long Island Sound 1/2 mile off Roanoke Point	Lat 41 00 30 Long 72 42 00	1	Flood	14		240
62	12.00	" " " "	Lat 41 00 30 Long 72 42 00	20	Flood	14		110
63	1.00	In Long Island Sound 1/2 mile off Heroda Point	Lat 40 59 45 Long 72 49 45	1	Flood	14		320
64	1.00	" " " "	Lat 40 47 45 Long 72 49 45	20	Flood	14		140
65	2.00	In Long Island Sound 1/2 mile off Woodville Landing	Lat 40 59 30 Long 72 49 45	1	Flood	16		380
66	2.00	" " " "	Lat 40 59 30 Long 72 49 45	20	Flood	14		160
67	3.00	In Long Island Sound 1/2 mile off Mt. Misery Point	Lat 40 59 30 Long 72 57 30	1	Flood	16		440
68	3.00	" " " "	Lat 40 59 30 Long 72 57 30	20	Flood	16		280

Number of Bacteria in the Water. Long Island Sound. April 15, 1909.

Low water occurred at Governors Island at 10.00 a.m. The wind was northwest with a velocity from 5 to 15 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
69	4.15	Smithtown Bay	Lat 40 58 00 Long 73 10 45	1	Flood		20	420
70	4.15	" "	Lat 40 58 00 Long 73 10 45	20	Flood		20	180
71	5.00	Long Island Sound 1 mile off Eatons Point	Lat 40 59 30 Long 73 22 30	1	Flood		20	360
72	5.00	" " " " "	Lat 40 59 30 Long 73 22 30	20	Flood		20	120
73	6.00	Long Island Sound 1 mile off Lloyds Point	Lat 40 57 45 Long 73 29 10	1	Flood		22	480
74	6.00	" " " " "	Lat 40 57 45 Long 73 29 10	20	Flood		22	220
75	7.00	Long Island Sound 1 mile off Matinicock Point	Lat 40 55 20 Long 73 38 25	1	Flood		24	460
76	7.00	" " " " "	Lat 40 55 20 Long 73 38 25	20	Flood		24	240
77	8.00	Long Island Sound 1 mile off Prospect Point	Lat 40 52 45 Long 73 44 25	1	Ebb		26	540
78	8.00	" " " " " "	Lat 40 52 45 Long 73 44 25	20	Ebb		26	320
79	9.00	Long Island Sound 100 feet off Throgs Neck	Lat 40 48 12 Long 73 47 35	1	Ebb		30	1,080
80	9.00	" " " " "	Lat 40 48 12 Long 73 47 35	20	Ebb		30	540
81	10.00	East River 500 feet off Clauson Point	Lat 40 48 15 Long 73 50 50	1	Ebb		36	2,230
82	10.00	" " " " "	Lat 40 48 15 Long 73 50 50	20	Ebb		36	1,200
83	11.00	East River under Williamsburg Bridge	Lat 40 42 49 Long 73 58 21	1	Ebb		40	10,300
84	11.00	" " " "	Lat 40 42 49 Long 73 58 21	20	Ebb		40	3,200

Number of Bacteria in the Water. The Narrows. April 19, 1909.

Low water occurred at Governors Island at 1.35 p.m. The wind was southwest with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per c.c.
85	10.15	Near shore Fort Hamilton	Lat 40 36 27 Long 74 02 13	1	Ebb			6,400
86	10.18	" "	Lat 40 36 27 Long 74 02 13	10	"			4,700
87	10.25	¼ way across Narrows from Fort Hamilton	Lat 40 36 27 Long 74 02 34	1	"			5,300
88	10.28	" "	Lat 40 36 27 Long 74 02 34	10	"			3,700
89	10.31	" "	Lat 40 36 27 Long 74 02 34	20	"			2,200
90	10.34	" "	Lat 40 36 27 Long 74 02 34	40	"			950
91	10.40	" "	Lat 40 36 27 Long 74 02 34	80	"			480
92	10.55	¼ way across Narrows	Lat 40 36 25 Long 74 02 48	1	"			4,200
93	10.58	" "	Lat 40 36 25 Long 74 02 48	10	"			2,800
94	11.05	" "	Lat 40 36 25 Long 74 02 48	20	"			1,900
95	11.10	" "	Lat 40 36 25 Long 74 02 48	40	"			840
96	11.15	" "	Lat 40 36 25 Long 74 02 48	80	"			620
97	11.25	¼ way across Narrows from Fort Hamilton	Lat 40 36 23 Long 74 03 02	1	"			19,000
98	11.28	" "	Lat 40 36 23 Long 74 03 02	10	"			13,000
99	11.31	" "	Lat 40 36 23 Long 74 03 02	20	"			8,600

Number of Bacteria in the Water. The Narrows. April 19, 1909.
(Continued)

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
100	11.38	½ way across Narrows from Fort Hamilton	Lat 40 36 23 Long 74 03 02	40	Ebb			2,800
101	11.40	" "	Lat 40 36 23 Long 74 03 02	80	"			1,600
102	11.50	50 feet from Fort Wadsworth	Lat 40 36 21 Long 74 03 13	1	"			22,000
103	11.53	" "	Lat 40 36 21 Long 74 03 13	10	"			17,000
104	12.00	" "	Lat 40 36 21 Long 74 03 13	20	"			9,500
105	12.05	" "	Lat 40 36 20 Long 74 03 13	40	"			2,200
106	3.32	Near shore Fort Hamilton	Lat 40 36 27 Long 74 03 14	1	Flood			4,200
107	3.35	" "	Lat 40 36 27 Long 74 02 13	10	"			2,600
108	3.43	½ way across Narrows from Fort Hamilton	Lat 40 36 27 Long 74 02 13	1	"			3,700
109	3.46	" "	Lat 40 36 27 Long 74 02 34	10	"			3,200
110	3.48	" "	Lat 40 36 27 Long 74 02 34	20	"			2,000
111	3.51	" "	Lat 40 36 27 Long 74 02 34	40	"			850
112	3.54	" "	Lat 40 36 27 Long 74 02 34	80	"			340
113	4.00	½ way across Narrows	Lat 40 36 25 Long 74 02 48	1	"			2,800
114	4.03	" "	Lat 40 36 25 Long 74 02 48	10	"			1,900
115	4.08	" "	Lat 40 36 25 Long 74 02 48	20	"			1,600

Number of Bacteria in the Water. The Narrows. April 19. 1909.

(Continued).

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
116	4.07	½ way across Narrows	Lat 40 36 25	40	Flood			550
			Long 74 02 48					
117	4.10	" "	Lat 40 36 25	80	"			380
			Long 74 02 48					
118	4.16	½ way across Narrows from Ft. Hamilton	Lat 40 36 23	1	"			4,200
			Long 74 03 02					
119	4.18	" "	Lat 40 36 23	10	"			3,900
			Long 74 03 02					
120	4.20	" "	Lat 40 36 23	20	"			2,200
			Long 74 03 02					
121	4.23	" "	Lat 40 36 23	40	"			1,200
			Long 74 03 02					
122	4.25	" "	Lat 40 36 23	80	"			480
			Long 74 03 02					
123	4.31	50 feet from Fort Wadsworth	Lat 40 36 20	1	"			5,600
			Long 74 03 14					
124	4.34	" "	Lat 40 36 20	10	"			4,200
			Long 74 03 14					
125	4.37	" "	Lat 40 36 20	20	"			2,600
			Long 74 03 14					
126	4.40	" "	Lat 40 36 20	40	"			860
			Long 74 03 14					

Number of Bacteria in the Water. East River. April 22, 1909.

High water occurred at Governors Island at 9.49 a.m. The wind was southwest with a velocity of 8 miles per hour from 8.05 a.m. till 1.55 p.m. From 1.55 p.m. the velocity was 15 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Location of Samples: Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per c.c.
127	8.05	30 feet off Pier 10 Manhattan	Lat 40 42 10 Long 74 00 23	1	Flood			8,800
128	8.09	"	Lat 40 42 10 Long 74 00 23	10	"			7,400
129	8.12	"	Lat 40 42 10 Long 74 00 23	20	"			5,300
130	8.17	"	Lat 40 42 10 Long 74 00 23	35	"			3,200
131	8.25	¼ way across East River, Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	"			7,700
132	8.28	"	Lat 40 42 07 Long 74 00 17	10	"			6,900
133	8.32	"	Lat 40 42 07 Long 74 00 17	20	"			6,400
134	8.37	"	Lat 40 42 07 Long 74 00 17	40	"			8,600
135	8.45	½ way across East River	Lat 40 42 03 Long 74 00 11	1	"			7,200
136	8.48	"	Lat 40 42 03 Long 74 00 11	10	"			5,800
137	8.52	"	Lat 40 42 03 Long 74 00 11	20	"			5,800
138	8.57	"	Lat 40 42 03 Long 74 00 11	40	"			3,700
139	9.10	¾ way across East River, Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	1	"			10,000

Number of Bacteria in the Water. East River. (Continued) April 28. 1909.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
140	9.13	¼ way across East River, Pier 10, Manhattan	Lat 40 42 00 Long 74 00 05	10	Flood			7,900
141	9.18	" "	Lat 40 42 00 Long 74 00 05	20	"			7,400
142	9.23	" "	Lat 40 42 00 Long 74 00 05	40	"			6,400
143	9.30	30 feet off Pier, Brooklyn.	Lat 40 41 57 Long 73 59 59	1	"			13,000
144	9.35	" "	Lat 40 41 57 Long 73 59 59	10	"			8,800
145	9.37	" "	Lat 40 41 57 Long 73 59 59	20	"			4,900
146	9.42	" "	Lat 40 41 57 Long 73 59 59	40	"			4,200
147	1.00	30 feet off Pier, Manhattan 10	Lat 40 42 10 Long 74 00 23	1	Ebb			10,000
148	1.02	" "	Lat 40 42 10 Long 74 00 23	10	"			7,900
149	1.05	" "	Lat 40 42 10 Long 74 00 23	20	"			6,400
150	1.08	" "	Lat 40 42 10 Long 74 00 23	38	"			4,800
151	1.12	¼ way across East River, Pier 10, Manhattan	Lat 40 42 07 Long 74 00 17	1	"			8,000
152	1.14	" "	Lat 40 42 07 Long 74 00 17	10	"			7,400
153	1.17	" "	Lat 40 42 07 Long 74 00 17	20	"			6,400
154	1.20	" "	Lat 40 42 07 Long 74 00 17	40	"			8,300
155	1.25	¼ way across East River	Lat 40 42 03 Long 74 00 11	1	"			10,000

Number of Bacteria in the Water. East River. (Continued) April 22, 1909.

Sample No.	Hour p.m.	Location of Sample — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
156	1.27	½ way across East River	Lat 40 42 03 Long 74 00 11	10	Ebb			9,400
157	1.30	" "	Lat 40 42 03 Long 74 00 11	20	Ebb			6,400
158	1.33	" "	Lat 40 42 03 Long 74 00 11	40	Ebb			8,300
159	1.40	¼ way across East River from Pier 10, Manhattan	Lat 40 42 00 Long 74 00 08	1	Ebb			10,200
160	1.42	" "	Lat 40 42 00 Long 74 00 08	10	Ebb			9,800
161	1.45	" "	Lat 40 42 00 Long 74 00 08	20	Ebb			8,800
162	1.48	" "	Lat 40 42 00 Long 74 00 08	40	Ebb			8,300
163	1.55	30 feet off Pier 10, Brooklyn	Lat 40 41 57 Long 73 59 59	1	Ebb			12,900
164	1.57	" "	Lat 40 41 57 Long 73 59 59	10	Ebb			10,000
165	2.00	" "	Lat 40 41 57 Long 73 59 59	20	Ebb			7,900
166	2.05	" "	Lat 40 41 57 Long 73 59 59	40	Ebb			7,400

Ex. 98. P. 13.

PEOPLE OF STATE OF NEW YORK vs. ASHLEY W. COWAN ET AL. 5998

Number of Bacteria in the Water. Kill Van Kull. April 26. 1909.

High water occurred at Governors Island at 1.39 p.m. The wind was northeast from 9.50 a.m. until 11.00 a.m. with a velocity of 10 miles per hour. From 3.04 p.m. to 4.10 p.m. the wind was northeast with a velocity of 15 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
167	9.50	20 feet off Columbia Oil Co. Pier, Bayonne	Lat 40 39 02 Long 74 05 26	1	Flood			6,400
168	9.53	" "	Lat 40 39 02 Long 74 05 26	10	"			4,200
169	9.57	" "	Lat 40 39 02 Long 74 05 26	20	"			3,700
170	10.03	¼ way from Bayonne	Lat 40 39 00 Long 74 05 26	1	"			5,300
171	10.05	" "	Lat 40 39 00 Long 74 05 26	10	"			3,200
172	10.08	" "	Lat 40 39 00 Long 74 05 26	20	"			2,600
173	10.12	" "	Lat 40 39 00 Long 74 05 26	40	"			1,600
174	10.17	½ way across Kill Van Kull	Lat 40 38 57 Long 74 05 25	1	"			7,400
175	10.19	" "	Lat 40 38 57 Long 74 05 25	10	"			6,400
176	10.23	" "	Lat 40 38 57 Long 74 05 25	20	"			4,200
177	10.28	" "	Lat 40 38 57 Long 74 05 25	40	"			3,200
178	10.33	¾ way across from Bayonne	Lat 40 38 54 Long 74 05 24	1	"			10,000
179	10.35	" "	Lat 40 38 54 Long 74 05 24	10	"			7,900
180	10.38	" "	Lat 40 38 54 Long 74 05 24	20	"			5,800

Number of Bacteria in the Water. Kill Van Kull. April 26, 1909.
(Continued)

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
181	10.45	¼ way across from Bayonne	Lat 40 38 54 Long 74 05 24	40	Flood			4,800
182	10.55	20 feet off dock foot Jersey St. New Brighton, S.I.	Lat 40 38 51 Long 74 05 23	1	Flood			12,900
183	11.00	" "	Lat 40 38 51 Long 74 05 23	10	Flood			7,400
184	3.04	20 ft. from Columbia Oil Co. Pier Bayonne	Lat 40 39 02 Long 74 05 26	1	Ebb			8,500
185	3.07	" "	Lat 40 39 02 Long 74 05 26	10	"			6,900
186	3.10	" "	Lat 40 39 02 Long 74 05 26	20	"			4,200
187	3.18	½ way across Kil Van Kull from Bayonne	Lat 40 39 02 Long 74 05 26	1	"			7,900
188	3.22	" "	Lat 40 39 00 Long 74 05 26	10	"			6,900
189	3.25	" "	Lat 40 39 00 Long 74 05 26	20	"			6,800
190	3.28	" "	Lat 40 39 00 Long 74 05 26	40	"			3,700
191	3.36	½ way across Kill van Kull	Lat 40 38 57 Long 74 05 25	1	"			10,600
192	3.39	½ way across Kill Van Kull	Lat 40 38 57 Long 74 05 25	10	"			8,500
193	3.42	" "	Lat 40 38 57 Long 74 05 25	20	"			6,400
194	3.45	"	Lat 40 38 57 Long 74 05 25	40	"			4,800
195	3.52	¼ way across Kill Van Kull from Bayonne	Lat 40 38 54 Long 74 05 24	1	"			13,000
196	3.54	" "	Lat 40 38 54 Long 74 05 24	10	"			10,600
197	3.57	" "	Lat 40 38 54 Long 74 05 24	20	"			9,000

Ex. 95. P. 15.

Number of Bacteria in the Water. Kill Van Kull April 26. 1909.
(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
198	4.00	¾ way across Kill Van Kull	Lat 40 38 54 Long 74 05 24	40	Ebb			6,400
199	4.05	20 feet off dock foot Jersey St. New Brighton, S.I.	Lat 40 38 51 Long 74 05 23	1	"			15,900
200	4.10	" "	Lat 40 38 51 Long 74 05 23	10	"			11,000

Ex. 95. P. 16

Number of Bacteria in the Water. Harlem River. April 27, 1909.

High water occurred at Governors Island at 2.32 p.m. The wind was northwest with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
201	11.06	At Third Av. Bridge 10 feet from east shore	Lat 40 48 27 Long 73 55 55	1	Flood			20,000
202	11.08	" "	Lat 40 48 27 Long 73 55 55	10	"			13,000
203	11.16	At Third Av. Bridge 1/4 way across from east shore	Lat 40 48 26 Long 73 55 56	1	"			18,000
204	11.19	" "	Lat 40 48 26 Long 73 55 56	10	"			14,000
205	11.22	" "	Lat 40 48 26 Long 73 55 56	20	"			10,000
206	11.30	At Third Av. bridge, midstream	Lat 40 48 25 Long 73 55 57	1	"			12,000
207	11.32	" "	Lat 40 48 25 Long 73 55 57	10	"			8,500
208	11.35	" "	Lat 40 48 25 Long 73 55 57	20	"			6,400
209	11.44	At Third Av. bridge, ¼ way across from east shore	Lat 40 48 25 Long 73 55 58	1	"			13,000
210	11.47	" "	Lat 40 48 25 Long 73 55 58	10	"			9,500
211	11.50	" "	Lat 40 48 25 Long 73 55 58	20	"			6,400
212	12.00	At Third Av. Bridge, 10 feet from west shore	Lat 40 48 25 Long 73 56 00	1	"			19,000
213	12.02	" "	Lat 40 48 25 Long 73 56 00	10	"			14,000
214	12.05	" "	Lat 40 48 25 Long 73 56 00	18	"			7,400

Number of Bacteria in the Water, Harlem River. April 27, 1909.
(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	No. of bacteria per c.c.
215	4.34	At Third Av. Bridge 10 feet from east shore	Lat 40 48 27 Long 73 55 55	1	Ebb		13,000
216	4.36	" "	Lat 40 48 27 Long 73 55 55	10	"		2,500
217	4.42	At Third Av. Bridge ¼ way across from east shore	Lat 40 48 26 Long 73 55 56	1	"		11,000
218	4.44	" "	Lat 40 48 26 Long 73 55 56	10	"		8,500
219	4.46	" "	Lat 40 48 26 Long 73 55 56	20	"		5,300
220	4.50	At Third Av. Bridge, midstream	Lat 40 48 25 Long 73 55 57	1	"		9,500
221	4.52	" "	Lat 40 48 25 Long 73 55 57	10	"		7,400
222	4.54	" "	Lat 40 48 25 Long 73 55 57	20	"		4,200
223	4.58	At Third Av. Bridge, ¾ way across from east shore	Lat 40 48 25 Long 73 55 58	1	"		12,000
224	5.00	" "	Lat 40 48 25 Long 73 55 58	10	"		9,000
225	5.02	" "	Lat 40 48 25 Long 73 55 58	20	"		6,400
226	5.06	At Third Av. Bridge, 10 feet from west shore	Lat 40 48 25 Long 73 56 00	1	"		17,000
227	5.08	" "	Lat 40 48 25 Long 73 56 00	10	"		11,000
228	5.10	" "	Lat 40 48 25 Long 73 56 00	18	"		7,400

Number of Bacteria in the Water. Hudson River. May 3, 1909

Low water occurred at Governors Island at 12.50 p. m. The wind was southeast with a velocity of from 20 to 30 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
229	12.06	50 feet off pier on New Jersey shore opposite Riverdale Sta.	Lat 40 54 14 Long 73 55 50	1	Ebb			5,900
230	12.06	50 feet off pier on New Jersey shore opposite Riverdale Sta.	Lat 40 54 14 Long 73 55 50	10	Ebb			5,800
231	12.11	50 feet off pier on New Jersey shore opposite Riverdale Sta.	Lat 40 54 14 Long 73 55 50	16	Ebb			4,400
232	12.20	1/4 way across Hudson River from New Jersey shore	Lat 40 54 12 Long 73 55 42	1	Ebb			5,500
233	12.20	1/4 way across Hudson River from New Jersey shore	Lat 40 54 12 Long 73 55 42	10	Ebb			4,900
234	12.38	1/4 way across Hudson River from New Jersey shore	Lat 40 54 12 Long 73 55 42	20	Ebb			3,700
235	1.00	1/2 way across Hudson River	Lat 40 54 08 Long 73 55 28	1	Ebb			6,300
236	1.08	1/2 way across Hudson River	Lat 40 54 08 Long 73 55 28	10	Ebb			5,300
237	1.08	1/2 way across Hudson River	Lat 40 54 08 Long 73 55 28	20	Ebb			4,400
238	1.12	1/2 way across Hudson River	Lat 40 54 08 Long 73 55 28	30	Ebb			2,700
239	1.22	3/4 way across Hudson River from New Jersey shore	Lat 40 54 06 Long 73 55 10	1	Ebb			9,400
240	1.26	3/4 way across Hudson River from New Jersey shore	Lat 40 54 06 Long 73 55 10	10	Ebb			6,460
241	1.32	3/4 way across Hudson River from New Jersey shore	Lat 40 54 06 Long 73 55 10	20	Ebb			4,800
242	1.37	3/4 way across Hudson River from New Jersey shore	Lat 40 54 06 Long 73 55 10	40	Ebb			3,700

Number of Bacteria in the Water, Hudson River. May 3, 1909.
(Continued)

Sample No.	Hour p.m.	Location of Samples: Location	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
243	1.54	30 feet off pier at Riverdale Station	Lat 40 54 03 Long 73 54 57	1	Ebb			18,000
244	1.57	" "	Lat 40 54 03 Long 73 54 57	10	"			9,800
245	5.15	80 feet off pier New Jersey opposite Riverdale Station	Lat 40 54 14 Long 73 55 50	1	Flood			4,900
246	5.17	" "	Lat 40 54 14 Long 73 55 50	10	"			3,800
247	5.20	" "	Lat 40 54 14 Long 73 55 50	18	"			3,800
248	5.27	¼ way across Hudson from New Jersey shore	Lat 40 54 12 Long 73 55 48	1	"			4,700
249	5.29	" "	Lat 40 54 12 Long 73 55 42	10	"			4,800
250	5.32	" "	Lat 40 54 12 Long 73 55 48	20	"			3,700
251	5.42	½ way across Hudson River	Lat 40 54 09 Long 73 55 28	1	"			3,300
252	5.44	" "	Lat 40 54 09 Long 73 55 28	10	"			4,700
253	5.47	" "	Lat 40 54 09 Long 73 55 28	20	"			3,700
254	5.50	" "	Lat 40 54 09 Long 73 55 28	30	"			3,200
255	5.59	¾ way across Hudson River from New Jersey shore	Lat 40 54 06 Long 73 55 10	1	"			6,900
256	6.02	" "	Lat 40 54 06 Long 73 55 10	10	"			6,400
257	6.05	" "	Lat 40 54 06 Long 73 55 10	20	"			3,700

Number of Bacteria in the Water. Hudson River. May 3, 1909.
(Continued)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of bacteria per C.C.
258	6.08	¼ way across Hudson River from New Jersey shore	Lat	40 54 06		40	Flood			4,200
			Long	73 55 10						
259	6.16	30 feet off pier at Riverdale Station, N.Y.C.R.R.	Lat	40 54 03		1	Flood			7,400
			Long	73 54 57						
260	6.20	" "	Lat	40 54 03		10	"			5,800
			Long	73 54 57						

Ex. 95. P. 21.

Number of Bacteria inthe Water. Hudson River. May 4, 1909.

Low water occurred at Governors Island at 1.53 p.m. The wind was southwest with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of bacteria per C.C.
261	10.00	Hudson River midstream oppt. Riverdale Station, N.Y.C.RR	Lat 40 54 08 Long 73 55 28	1	Ebb			7,400
262	10.03	" "	Lat 40 54 08 Long 73 55 28	10	"			5,800
263	10.05	" "	Lat 40 54 08 Long 73 55 28	30	"			3,700
264	0.20	1000 feet off East shore opposite Spuyton Duyvil Creek.	Lat 40 52 48 Long 73 56 45	1	"			5,800
265	10.22	" "	Lat 40 52 48 Long 73 55 45	10	"			4,700
266	10.24	" "	Lat 40 52 48 Long 73 55 45	30	"			3,200
267	10.34	1000 ft. off East shore Inn-wood Station, N.Y.C.R.R.	Lat 40 52 13 Long 73 56 09	1	"			5,300
268	10.35	" "	Lat 40 52 13 Long 73 56 09	10	"			4,200
269	10.37	" "	Lat 40 52 13 Long 73 56 09	30	"			2,600
270	10.57	500 ft. off East shore opposite Fort Washington Pt.	Lat 40 51 02 Long 73 56 55	1	"			5,400
271	10.58	" "	Lat 40 51 02 Long 73 56 55	10	"			4,700
272	11.00	" "	Lat 40 51 02 Long 73 56 55	30	"			4,200
273	11.14	1000 ft. off East shore opposite W. 167 St.	Lat 40 50 14 Long 73 57 09	1	"			5,800
274	11.15	" "	Lat 40 50 14 Long 73 57 09	10	"			6,400

Number of Bacteria in the Water. Hudson River. (Continued) May 4, 1909.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of bacteria per C.C.
275	11.17	1000 ft. off East shore opposite W. 157 St.	Lat 40 50 14 Long 73 57 09	30	Ebb			3,700
276	11.47	1000 feet off East shore opposite W. 92 St.	Lat 40 47 44 Long 73 58 58	1	Ebb			6,600
277	11.48	" "	Lat 40 47 44 Long 73 58 55	10	"			5,300
278	11.50	" "	Lat 40 47 44 Long 73 58 55	30	"			2,800
279	12.20	1000 feet off East shore opposite W. 62 St.	Lat 40 46 37 Long 73 59 51	1	"			7,400
280	12.21	" "	Lat 40 46 37 Long 73 59 51	10	"			5,800
281	12.23	" "	Lat 40 46 37 Long 73 59 51	30	"			3,700
282	12.43	1000 feet off East shore opposite W. 42 St.	Lat 40 45 50 Long 74 00 22	1	"			8,500
283	12.44	" "	Lat 40 45 50 Long 74 00 22	10	"			7,600
284	12.45	" "	Lat 40 45 50 Long 74 00 22	30	"			3,200
285	1.04	200 feet off East shore opposite W. 23 St.	Lat 40 45 03 Long 74 00 43	1	"			9,500
286	1.05	" "	Lat 40 45 03 Long 74 00 43	10	"			7,900
287	1.07	" "	Lat 40 45 03 Long 74 00 43	30	"			4,200
288	1.22	200 feet off East shore opposite Gansevoort St.	Lat 40 44 21 Long 74 00 51	1	"			6,400
289	1.23	" "	Lat 40 44 21 Long 74 00 51	10	"			8,000

Number of Bacteria in the Water. Hudson River. May 4, 1909.
(Continued)

Sample No.	Hour p.m.	Location of Samples Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
290	1.25	200 feet off East shore opposite Gansvoort St.	Lat 40 44 21 Long 74 00 51	30	Ebb			3,600
291	1.40	200 feet off East shore, oppt pier 37 Charlton St.	Lat 40 43 41 Long 74 00 55	1	"			9,000
292	1.41	" "	Lat 40 43 41 Long 74 00 56	10	"			9,200
293	1.43	" "	Lat 40 43 41 Long 74 00 55	30	"			1,700
294	2.03	200 feet off East shore,oppt-pier 21, Duane St.	Lat 40 43 06 Long 74 01 01	1	"			9,500
295	2.04	" "	Lat 40 43 06 Long 74 01 01	10	"			9,000
296	2.05	" "	Lat 40 43 06 Long 74 01 01	30	"			5,500
297	2.16	300 feet off East shore,oppt-Liberty St.	Lat 40 42 41 Long 74 01 03	1	"			9,200
298	2.17	" "	Lat 40 42 41 Long 74 01 03	10	"			7,900
299	2.18	" "	Lat 40 42 41 Long 74 01 03	30	"			4,600
300	2.28	100 feet off East shore,oppt-pier A	Lat 40 42 16 Long 74 01 09	1	"			10,500
301	2.30	" "	Lat 40 42 16 Long 74 01 09	10	"			8,500
302	2.32	" "	Lat 40 42 16 Long 74 01 09	30	"			4,200
303	2.45	500 feet West of Castle William Governors Island	Lat 40 41 35 Long 74 01 19	1	"			8,900
304	2.47	" "	Lat 40 41 35 Long 74 01 19	10	"			4,800
305	2.50	" "	Lat 40 41 35 Long 74 01 19	30	"			2,600

Number of Bacteria in the Water. Newark Bay and Passaic River May 13, 1909.

High water at Governors Island at 8.40 p. m. The wind until 1.02 p. m. was south with a velocity of 10 miles per hour. At 3.45 p. m. the velocity was 40 miles per hour.

Sample No.	Hour A.M.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
306	10.45	200 feet from Bergen Point shore at C.R.R. of N.J. bridge	Lat 40 39 17 Long 74 08 26	1	Flood			6,400
307	10.47	200 feet from Bergen Point shore at C.R.R. of N.J. bridge	Lat 40 39 17 Long 74 08 06	10	"			5,300
308	10.53	¼ way across Newark Bay near drawbridge C.R.R. of N.J.	Lat 40 39 17 Long 74 08 46	1	"			4,800
309	10.55	¼ way across Newark Bay near drawbridge C.R.R. of N.J.	Lat 40 39 17 Long 74 08 46	10	"			3,700
310	10.57	¼ way across Newark Bay near drawbridge C.R.R. of N.J.	Lat 40 39 17 Long 74 08 46	20	"			3,200
311	11.03	½ way across Newark Bay on line C.R.R. of N.J. bridge	Lat 40 39 17 Long 74 09 14	1	"			2,800
312	11.05	½ way across Newark Bay on line C.R.R. of N.J. bridge	Lat 40 39 17 Long 74 09 14	10	"			2,200
313	11.10	¾ way across Newark Bay from east shore	Lat 40 39 17 Long 74 09 40	1	"			5,400
314	11.12	¾ way across Newark Bay from east shore	Lat 40 39 17 Long 74 09 40	10	"			4,200
315	11.16	300 feet from west shore Elizabethport	Lat 40 39 16 Long 74 10 02	1	"			6,700
316	11.20	300 feet from west shore Elizabethport	Lat 40 39 16 Long 74 10 02	10	"			5,200
317	11.35	At red bell buoy in channel between C.R.R. of N.J. and B. & O. R. R. bridge	Lat 40 40 15 Long 74 08 10	1	"			3,800

Number of Bacteria in Water. Newark Bay and Passaic River. May 18, 1909.

High water at Governors Island at 8.40 p.m. The wind until 1.08 p.m. was south with a velocity of 10 miles per hour. At 3.48 p.m. the velocity was 40 miles per hour.

Sample No.	Location of Samples: EDST A.M.	Approximate	Exact	Feet below surface	Tidal Current	Temp. water deg.C.	Percent land water	No. of Bacteria per c.c.
			° ' "					
318	11.37	At red bell buoy in channel between C.R.R. of N.J. and B. & O.R.R. bridge	Lat 40 40 16 Long 74 08 10	10	Flood			3,100
319	11.40	At red bell buoy in channel between C.R.R. of N.J. and B.& O.R.R. bridge	Lat 40 40 15 Long 74 08 10	20	"			1,100
320	12.00	At drawbridge B. & O.R.R.	Lat 40 41 56 Long 74 07 15	1	"			6,400
	P.M.	bridge in channel of bay						
321	12.08	At drawbridge B.& O.R.R. bridge in channel of bay	Lat 40 41 56 Long 74 07 15	10	"			8,000
322	12.08	At drawbridge B.& O.R.R. bridge in channel of bay	Lat 40 41 56 Long 74 07 15	20	"			2,600
323	12.20	Passaic River at drawbridge N.Y. and Newark R.R. in channel	Lat 40 43 21 Long 74 07 18	1	"			12,800
324	12.28	Passaic River at drawbridge N.Y. and Newark R.R. in Channel	Lat 40 43 21 Long 74 07 18	10	"			10,000
325	12.38	Passaic River just above P.R.R. freight bridge	Lat 40 44 10 Long 74 09 48	1	"			18,000
326	12.40	Passaic River just above P.R.R. freight bridge below Newark	Lat 40 44 10 Long 74 09 48	10	"			13,000

Number of Bacteria in Water — Newark Bay and Passaic River — May 13, 1909.

High water at Governors Island at 2.40 p. m. The wind until 1.02 p. m. was south with a velocity of 10 miles per hour. At 3.48 p. m. the velocity was 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	Number of Bacteria per cc.
327	1.00	Passaic River just below P.R.R. passenger bridge in Newark	Lat 40 44 49 Long 74 09 56	1	Flood			24,000
328	1.02	Passaic River just below P.R.R. passenger bridge in Newark	Lat 40 44 49 Long 74 09 56	10	"			11,000
329	3.10	Passaic River just below P.R.R. passenger bridge in Newark	Lat 40 44 49 Long 74 09 56	1	Ebb			60,000
330	3.12	Passaic River just below P.R.R. passenger bridge in Newark	Lat 40 44 49 Long 74 09 56	10	"			32,000
331	3.33	Passaic River just above P.R.R. freight bridge below Newark	Lat 40 44 10 Long 74 09 48	1	"			24,000
332	3.36	Passaic River just above P.R.R. breight bridge below Newark	Lat 40 44 10 Long 74 09 48	10	"			21,000
333	3.48	Passaic River at drawbridge N.Y. & Newark R.R. in channel	Lat 40 43 21 Long 74 07 18	1	"			10,000
334	3.47	Passaic River at drawbridge N.Y. & Newark R.R. in channel	Lat 40 43 21 Long 74 07 18	10	"			12,000
335	4.00	At drawbridge of B. & O.R.R. bridge in channel of Newark Bay	Lat 40 41 56 Long 74 07 18	1	"			24,000
336	4.02	At drawbridge of B. & O. R.R. bridge in channel of Newark Bay	Lat 40 41 56 Long 74 07 18	10	"			13,000
337	4.04	At drawbridge of B. & O. R.R. bridge in channel of Newark Bay	Lat 40 41 56 Long 74 07 18	20	"			8,800

Number of Bacteria in Water — Newark Bay and Passaic River — May 13, 1909

High water at Governors Island at 2.40 p. m. The wind until 1.02 p. m. was south with a velocity of 10 miles per hour. At 3.45 p. m. the velocity was 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per CC.
338	4.20	At red bell buoy in channel in Bay between C.R.R. of N.J.and B.& O. R. R. bridges	Lat 40 40 15 Long 74 08 10	1	Ebb			8,500
339	4.22	At red bell buoy in channel in Bay between C.R.R. of N.J. and B.& O. R.R. bridges	Lat 40 40 15 Long 74 08 10	10	"			5,700
340	4.24	At red bell buoy in channel in Bay between C.R.R. of N.J. and B. & O. R.R. bridges	Lat 40 40 15 Long 74 08 10	20	"			4,200
341	4.35	200 feet from Bergen Point shore at C.R.R. of N. J. bridge	Lat 40 39 17 Long 74 08 26	1	"			8,400
342	4.37	200 feet from Bergen Point shore at C.R.R. of N.J. bridge	Lat 40 39 17 Long 74 08 26	10	"			6,200
343	4.42	At drawbridge C.R.R. of N.J. in channel about ¼ way across Bay	Lat 40 39 17 Long 74 08 46	1	"			5,300
344	4.44	At drawbridge C.R.R. of N.J. in channel about ¼ way across Bay	Lat 40 39 17 Long 74 08 46	10	"			4,200
345	4.46	At drawbridge C.R.R. of N.J. in channel about ¼ way across Bay	Lat 40 39 17 Long 74 08 46	20	"			2,800
346	4.51	¼ way across Newark Bay on line C.R.R. of N.J. Bridge	Lat 40 39 17 Long 74 09 14	1	"			4,700
347	4.53	¼ way across Newark Bay on line C.R.R. of N. J. Bridge	Lat 40 39 17 Long 74 09 14	10	"			3,600

Number of Bacteria in Water — Newark Bay and Passaic River — May 13, 1909

High water at Governors Island at 2.40 p. m The wind until 1.02 p. m. was south with a velocity of 10 miles per hour. At 3.45 p. m. the velocity was 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal Current	Temp. water Deg.	Percent land water	Number of Bacteria per cc.
		Approximate	Exact					
348	4.58	½ way across Newark Bay from east shore	Lat 40 39 17 Long 74 09 40	1	Ebb			6,800
349	5.00	½ way across Newark Bay from east shore	Lat 40 39 17 Long 74 09 40	10	"			5,500

Ex. 95. P. 29

Number of Bacteria in the Water — Hudson River — May 11, 1909.

High water occurred at Governors Island at 12.21 p. m. The wind was north with a velocity of 40 miles per hour.

Sample No.	Hour a. m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. water Deg. C	Percent land water	Number of Bacteria per cc.
			o ' "					
350	9.14	50 feet off Pier A, Hudson River	Lat 40 42 16 Long 74 01 08	1	Ebb			17,000
351	9.15	50 feet off Pier A, Hudson River	Lat 40 42 16 Long 74 01 08	10	"			12,500
352	9.16	50 feet off Pier A, Hudson River	Lat 40 42 16 Long 74 01 08	20	"			9,700
353	9.18	50 feet off Pier A, Hudson River	Lat 40 42 16 Long 74 01 08	40	"			7,300
354	9.23	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	1	"			14,500
355	9.24	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	10	"			10,500
356	9.25	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	20	"			8,400
357	9.27	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	40	"			6,600
358	9.32	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	1	"			11,000
359	9.33	½ way across Hudsen River	Lat 40 42 19 Long 74 01 34	10	"			9,500
360	9.34	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	20	"			8,600
361	9.36	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	40	"			5,300

Number of Bacteria in the Water Hudson River May 11, 1909

High water occurred at Governors Island at 12.21 p. m. The wind was north with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples		Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
		Approximate	Exact ° ' "	Feet below surface			
362	9.41	3/4 way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 49	1	Ebb		9,800
363	9.42	3/4 way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	10	"		8,800
364	9.43	3/4 way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	20	"		7,800
365	9.45	3/4 way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	40	"		4,800
366	9.50	50 feet from C.R.R.of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	1	"		12,000
367	9.52	50 feet from C.R.R.of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	10	"		11,800
368	9.54	50 feet from C.R.R.of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	20	"		7,800

Number of Bacteria in the Water Hudson River May 12, 1909

High water at Governors Island at 1.21 p. m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
		Approximate	Exact	Feet below surface				
369	3.15	50 feet off Pier A Hudson River	Lat 40 42 16 Long 74 01 08	1	Flood			8,600
370	3.16	50 feet off Pier A Hudson River	Lat 40 42 16 Long 74 01 08	10	"			7,900
371	3.17	50 feet off Pier A Hudson River	Lat 40 42 16 Long 74 01 08	20	"			6,800
372	3.19	50 feet off Pier A Hudson River	Lat 40 42 16 Long 74 01 08	40	"			5,200
373	3.23	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	1	"			7,600
374	3.24	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	10	"			7,100
375	3.25	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	20	"			5,400
376	3.27	¼ way across Hudson River from Pier A	Lat 40 42 17 Long 74 01 20	40	"			5,200
377	3.31	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	1	"			6,400
378	3.32	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	10	"			6,200
379	3.33	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	20	"			4,700
380	3.35	½ way across Hudson River	Lat 40 42 19 Long 74 01 34	40	"			3,800
381	3.39	¾ way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	1	"			5,800

Number of Bacteria in the Water Hudson River May 15, 1909.

High water at Governors Island at 1.21 p. m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
		Approximate	Exact	Feet below surface				
582	3.40	¼ way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	10	Flood			5,300
583	3.41	½ way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	20	"			4,700
584	3.43	¾ way across Hudson River from Pier A	Lat 40 42 21 Long 74 01 48	40	"			3,600
585	3.47	80 feet from C.R.R. of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	1	"			7,200
586	3.48	80 feet from C.R.R. of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	10	"			5,600
587	3.50	80 feet from C.R.R. of N.J. Pier 5 Jersey City	Lat 40 42 22 Long 74 02 01	20	"			4,700

Bu. Wa. J. XX.

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3695

Number of Bacteria in the Water, Upper Bay, Lower Bay and Atlantic Ocean, May 18, 1909.

High water occurred at Governors Island at 2.40 p.m. The wind was south with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
388	9.00	At red spar buoy in Hudson River opposite Pier A	Lat 40 42 12 Long 74 01 19	1	Ebb			18,000
389	9.01	At red spar buoy in Hudson River opposite Pier A	Lat 40 42 12 Long 74 01 19	10	Ebb			14,000
390	9.02	At red spar buoy in Hudson River opposite Pier A	Lat 40 42 12 Long 74 01 19	20	Ebb			11,000
391	9.04	At red spar buoy in Hudson River opposite Pier A	Lat 40 42 12 Long 74 01 19	40	Ebb			9,800
392	9.30	Upper Bay, by spar buoy A off Red Hook, Brooklyn	Lat 40 40 43 Long 74 01 48	1	Ebb			12,000
393	9.31	Upper Bay, by spar buoy A off Red Hook, Brooklyn	Lat 40 40 43 Long 74 01 48	10	Ebb			10,000
394	9.32	Upper Bay, by spar buoy A off Red Hook, Brooklyn	Lat 40 40 43 Long 74 01 48	20	Ebb			9,800
395	9.33	Upper Bay, by spar buoy A off Red Hook, Brooklyn	Lat 40 40 43 Long 74 01 48	36	Ebb			6,400
396	9.46	Upper Bay by bell buoy 12 1/2	Lat 40 39 23 Long 74 03 14	1	Ebb			8,800
397	9.47	Upper Bay by bell buoy 12 1/2	Lat 40 39 23 Long 74 03 14	10	Ebb			7,800
398	9.48	Upper Bay by bell buoy 12 1/2	Lat 40 39 23 Long 74 03 14	20	Ebb			6,000
399	9.50	Upper Bay by bell buoy 12 1/2	Lat 40 39 23 Long 74 03 14	38	Ebb			5,800
400	10.08	Narrows, midway between Fort Lafayette and Fort Wadsworth	Lat 40 36 28 Long 74 02 48	1	Ebb			9,000
401	10.09	Narrows, midway between Fort Lafayette and Fort Wadsworth	Lat 40 36 28 Long 74 02 48	10	Ebb			8,000

PRESS OF STATE OF NEW YORK, ALBANY.

Number of Bacteria in the Water, Upper Bay, Lower Bay and Atlantic Ocean. (Continued.)

May 13, 1909.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
402	10.10	Narrows, midway between Fort Lafayette and Fort Wadsworth	Lat 40 36 25 Long 74 02 48	20	Ebb			5,500
403	10.12	Narrows, midway between Fort Lafayette and Fort Wadsworth	Lat 40 36 25 Long 74 02 48	40	Ebb			5,000
404	10.25	Lower Bay, by bell buoy Craven Shoal	Lat 40 35 08 Long 74 02 32	1	Ebb			8,500
405	10.26	Lower Bay, by bell buoy Craven Shoal	Lat 40 35 08 Long 74 02 32	10	Ebb			6,800
406	10.27	Lower Bay, by bell buoy Craven Shoal	Lat 40 35 08 Long 74 02 32	20	Ebb			6,300
407	10.30	Lower Bay, by bell buoy Craven Shoal	Lat 40 35 08 Long 74 02 32	40	Ebb			3,200
408	10.50	Lower Bay, by bell buoy A.C. 24 in Ambrose Channel	Lat 40 33 30 Long 74 01 25	1	Ebb			6,400
409	10.51	Lower Bay, by bell buoy A. C. 24 in Ambrose Channel	Lat 40 33 30 Long 74 01 25	10	Ebb			5,300
410	10.53	Lower Bay, by bell buoy A. C. 24 in Ambrose Channel	Lat 40 33 30 Long 74 01 25	20	Ebb			1,800
411	10.55	Lower Bay, by bell buoy A. C. 24 in Ambrose Channel	Lat 40 33 30 Long 74 01 25	40	Ebb			600
412	11.10	Lower Bay by bell buoy A. C. 18 in Ambrose Channel	Lat 40 32 00 Long 74 00 50	1	Flood			5,300
413	11.12	Lower Bay, by bell buoy A.C. 18 in Ambrose Channel	Lat 40 32 00 Long 74 00 50	10	Flood			3,100
414	11.14	Lower Bay, by bell buoy A.C. 18 in Ambrose Channel	Lat 40 32 00 Long 74 00 50	20	Flood			1,200
415	11.16	Lower Bay, by bell buoy A.C. 18 in Ambrose Channel	Lat 40 32 00 Long 74 00 50	40	Flood			640
416	11.35	Lower Bay, by bell buoy A.C. 12 in Ambrose Channel	Lat 40 31 05 Long 73 59 10	1	Flood			840

Number of Bacteria in the Water, Upper Bay, Lower Bay and Atlantic Ocean. (Continued.)

May 13, 1909.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
417	11.36	Lower Bay, by bell buoy A.C. 12 in Ambrose Channel	Lat	40	31	05	10	Flood			260
			Long	73	59	10					
418	11.38	Lower Bay, by bell buoy A.C. 12 in Ambrose Channel	Lat	40	31	05	20	Flood			360
			Long	73	59	10					
419	11.40	Lower Bay, by bell buoy A.C. 12 in Ambrose Channel	Lat	40	31	05	40	Flood			160
			Long	73	59	10					
420	12.30	Lower Bay, by gas buoy A.C.E. 2 outer end Ambrose Channel	Lat	40	29	50	1	Flood			500
			Long	73	56	15					
421	12.32	Lower Bay, by gas buoy A.C.E. 2 outer end Ambrose Channel	Lat	40	29	50	10	Flood			460
			Long	73	56	15					
422	12.34	Lower Bay, by gas buoy A.C.E. 2 outer end Ambrose Channel	Lat	40	29	50	20	Flood			400
			Long	73	56	15					
423	12.36	Lower Bay, by gas buoy A.C.E. 2 outer end Ambrose Cahnnel	Lat	40	29	50	40	Flood			220
			Long	73	56	15					
424	1.10	Atlantic Ocean by whistling buoy	Lat	40	28	45	1	Flood			600
			Long	73	53	35					
425	1.12	Atlantic Ocean by whistling buoy	Lat	40	28	45	10	Flood			200
			Long	73	53	35					
426	1.14	Atlantic Ocean by whistling buoy	Lat	40	28	45	20	Flood			340
			Long	73	53	35					
427	1.16	Atlantic Ocean by whistling buoy	Lat	40	28	45	40	Flood			110
			Long	73	53	35					

Number of Bacteria in the Water, Lower Bay. May 17,1909.

Low water occurred at Governors Island at 12.25 p.m. The wind southeast with a velocity of from 30 to 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria Per C.C.
428	12.30	At gas buoy, S 2 near Coney Is. shore	Lat 40 34 02 Long 73 59 20	1	Ebb			4,600
429	12.32	At gas buoy S 2 near Coney Is shore	Lat 40 34 02 Long 73 59 20	10	Ebb			3,600
430	12.35	At gas buoy S 2 near Coney Is. shore	Lat 40 34 02 Long 73 59 20	20	Ebb			1,900
431	1.04	About 1/2 mile from buoy S 2, on line	Lat 40 33 30 Long 73 59 05	1	Slack			3,800
432	1.07	About 1/2 mile from buoy S 2, on line	Lat 40 33 30 Long 73 59 05	10	Slack			2,900
433	1.10	About 1/2 mile from buoy S 2, on line	Lat 40 33 30 Long 73 59 05	15	Slack			2,800
434	1.21	About 1/2 mile from buoy S 2, on line	Lat 40 33 05 Long 73 58 45	1	Flood			3,200
435	1.23	About 1/2 mile from buoy S 2, on line	Lat 40 33 05 Long 73 58 45	10	Flood			2,600
436	1.25	About 1/2 mile from buoy S 2, on line	Lat 40 33 05 Long 73 58 45	20	Flood			1,600
437	2.00	About 1/2 mile farther on line	Lat 40 32 40 Long 73 58 45	1	Flood			2,200
438	2.02	About 1/2 mile farther on line	Lat 40 32 40 Long 73 58 45	10	Flood			1,600
439	2.05	About 1/2 mile farther on line	Lat 40 32 40 Long 73 58 45	16	Flood			1,200
440	2.31	About 1/2 mile farther on line	Lat 40 32 20 Long 73 58 20	1	Flood			2,400
441	2.33	About 1/2 mile farther on line	Lat 40 32 20 Long 73 58 20	10	Flood			1,700

Number of Bacteria in the Water, Lower Bay. (Continued.) May 17, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
442	2.36	About 1/2 mile farther on line	Lat 40 32 20 Long 73 58 20	20	Flood			1,200
443	3.11	About 1/2 mile farther on line	Lat 40 31 50 Long 73 58 15	1	Flood			2,100
444	3.13	About 1/2 mile farther on line	Lat 40 31 50 Long 73 58 15	10	Flood			1,800
445	3.15	About 1/2 mile farther on line	Lat 40 31 50 Long 73 58 15	20	Flood			1,000
446	3.35	About 1000 feet northwest of buoy A. C. 12, on line	Lat 40 29 50 Long 73 56 35	1	Flood			1,800
447	3.37	About 1000 feet northwest of buoy A. C. 12, on line	Lat 40 29 50 Long 73 56 35	10	Flood			1,200
448	3.40	About 1000 feet northwest of buoy A. C. 12, on line	Lat 40 29 50 Long 73 56 35	20	Flood			800
449	4.00	50 feet north of buoy A. C. 12	Lat 40 29 50 Long 73 56 25	1	Flood			1,400
450	4.02	50 feet north of buoy A. C. 12	Lat 40 29 50 Long 73 56 25	10	Flood			1,100
451	4.05	50 feet north of buoy A. C. 12	Lat 40 29 50 Long 73 56 25	16	Flood			900

Number of Bacteria in the Water, Lower Bay. May 18, 1909.

Low water occurred at Governors Island at 1.22 p.m. The wind was north until 1.29 p.m. with a velocity of from 8 to 10 miles per hour. From 1.49 p.m. the wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of samples — Approximate	Exact ° ' "	Feet below surface	Tidal Current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
82	10.00	100 feet south of buoy A. C. 12 in Ambrose Channel	Lat 40 29 45 Long 73 86 15	1	Neb			780
453	10.02	100 feet south of buoy A. C. 12 in Ambrose Channel	Lat 40 29 45 Long 73 86 15	10	Ebb			640
454	10.05	100 Feet south of buoy A.C. 12 in Ambrose Channel	Lat 40 29 45 Long 73 86 15	20	Ebb			400
455	10.07	100 feet south of buoy A. C. 12 in Ambrose Channel	Lat 40 29 45 Long 73 86 15	40	Ebb			320
456	10.18	Midway between buoy A.C. 12 and buoy N.B. 2	Lat 40 29 40 Long 73 87 15	1	Ebb			520
457	10.22	Midway between buoy A.C. 12 and buoy N.B. 2	Lat 40 29 40 Long 73 87 15	10	Ebb			480
458	10.24	Midway between buoy A.C. 12 and buoy N.B. 2	Lat 40 29 40 Long 73 87 15	20	Ebb			360
459	10.35	100 feet north of buoy N.B. 2 just outside Main Ship Channel	Lat 40 29 25 Long 73 88 30	1	Ebb			420
460	10.37	100 feet north of buoy N.B. 2 just outside Main Ship Channel	Lat 40 29 25 Long 73 88 30	10	Ebb			400
461	10.39	100 feet north of buoy N.B. 2 just outside Main Ship Channel	Lat 40 29 25 Long 73 88 30	20	Ebb			160
462	10.45	100 feet south of buoy N.B. 2 in Main Ship Channel	Lat 40 29 20 Long 73 88 25	1	Ebb			600
463	10.47	100 feet south of buoy N.B. 2 in Main Channel	Lat 40 29 20 Long 73 88 25	10	Ebb			820

Number of Bacteria in the Water, Lower Bay. (Continued.) May 10, 1909.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
464	10.49	100 feet south of buoy S.B. 2 in Main Ship Channel	Lat 40 29 26 Long 73 58 26	20	Ebb			280
468	11.03	100 feet south of buoy S 2 1/2 in Main Ship Channel	Lat 40 29 05 Long 73 59 25	1	Ebb			220
466	11.06	100 feet south of buoy S 2 1/2 in Main Ship Channel	Lat 40 29 05 Long 73 59 25	10	Ebb			240
467	11.07	100 feet south of buoy S 2 1/2 in Main Ship Channel	Lat 40 29 05 Long 73 59 25	20	Ebb			280
468	11.16	100 feet south of buoy N 4 in Main Ship Channel	Lat 40 29 00 Long 74 00 20	1	Ebb			700
469	11.18	100 feet south of buoy N 4 in Main Ship Channel	Lat 40 29 00 Long 74 00 20	10	Ebb			460
470	11.20	100 feet south of buoy N 4 in Main Ship Channel	Lat 40 29 00 Long 74 00 20	20	Ebb			340
471	11.21	100 feet south of buoy N 6 in Main Ship Channel	Lat 40 28 55 Long 74 00 45	1	Ebb			660
472	11.23	100 feet south of buoy N 6 in Main Ship Channel	Lat 40 28 55 Long 74 00 45	10	Ebb			780
473	11.36	100 feet south of buoy N 6 in Main Ship Channel	Lat 40 28 56 Long 74 00 45	20	Ebb			280
474	11.05	100 feet south of buoy N 8 in Main Ship Channel	Lat 40 28 45 Long 74 01 20	1	Ebb			480
475	11.37	100 feet south of buoy N 8 in Main Ship Channel	Lat 40 28 47 Long 74 01 20	10	Ebb			420
476	12.00	100 feet south of buoy N 8 in Main Ship Channel	Lat 40 28 45 Long 74 01 20	20	Ebb			260
477	12.45	100 feet south of buoy N 10 in Main Ship Channel	Lat 40 28 30 Long 74 02 10	1	Ebb			220
478	12.47	100 feet south of buoy N 10 in Main Ship Channel	Lat 40 28 30 Long 74 02 10	10	Ebb			200
479	12.50	100 feet south of buoy N 10 in Main Ship Channel	Lat 40 28 30 Long 74 02 10	20	Ebb			240

Number of Bacteria in the Water, Lower Bay. (Continued.) May 18, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
480	1.25	100 feet south of buoy N 12 in Main Ship Channel	Lat 40 28 36 Long 74 02 40	1	Slack			1,100
481	1.27	100 feet south of buoy N 12 in Main Ship Channel	Lat 40 28 36 Long 74 02 40	10	Slack			700
482	1.29	100 feet south of buoy N 12 in N in Ship Channel	Lat 40 28 36 Long 74 02 40	20	Slack			380
483	1.49	100 feet west of buoy N.C. 2 in Main Ship Channel	Lat 40 29 08 Long 74 02 48	1	Flood			1,800
484	1.52	100 feet west of buoy N.C. 2 in Main Ship Channel	Lat 40 29 08 Long 74 02 48	10	Flood			1,000
485	1.56	100 feet west of buoy N.C. 2 in Main Ship Channel	Lat 40 29 08 Long 74 02 48	20	Flood			800
486	2.10	100 feet west of buoy N.C. 4 in Main Ship Channel	Lat 40 29 38 Long 74 02 40	1	Flood			840
487	2.12	100 feet west of buoy N.C. 4 in Main Ship Channel	Lat 40 29 38 Long 74 02 40	10	Flood			600
488	2.15	100 feet west of buoy N.C. 4 i Main Ship Channel	Lat 40 29 38 Long 74 02 40	20	Flood			680
489	2.35	100 feet west of buoy N.C. 6 in Main Ship Channel	Lat 40 30 08 Long 74 02 40	1	Flood			2,200
490	2.37	100 feet west of buoy N.C. 6 in Main Ship Channel	Lat 40 30 08 Long 74 02 40	10	Flood			1,800
491	2.40	100 feet west of buoy N.C. 6 in Main Ship Channel	Lat 40 30 08 Long 74 02 40	20	Flood			900
492	2.55	100 feet west of buoy N.C. 8 in Main Ship Channel	Lat 40 30 40 Long 74 02 38	1	Flood			1,800
493	2.57	100 feet west of buoy N.C. 8 in Main Ship Channel	Lat 40 30 40 Long 74 02 38	10	Flood			1,100
494	3.00	100 feet west of buoy N.C. 8 in Main Ship Channel	Lat 40 30 40 Long 74 02 38	20	Flood			700
495	3.10	100 feet west of buoy N. in Main Ship Channel	Lat 40 31 18 Long 74 02 30	1	Flood			1,400

Number of Bacteria in the Water, Lower Bay. (Continued.) May 18, 1909.

Sample No	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
496	3.12	100 feet west of buey N in Main Ship Channel	Lat 40 31 15 Long 74 02 30	10	Flood			1,100
497	3.15	100 feet west of buey N in Main Ship Channel	Lat 40 31 15 Long 74 02 30	20	Flood			800
498	3.25	100 feet east of buoy C 9 in Main Ship Channel	Lat 40 31 55 Long 74 02 25	1	Flood			2,100
499	3.27	100 feet east of buey C 9 in Main Ship Channel	Lat 40 31 55 Long 74 02 25	10	Flood			1,800
500	3.30	100 feet east of buey C 9 in Main Ship Channel	Lat 40 31 55 Long 74 02 25	20	Flood			950
501	3.40	100 feet east of buey C 9 1/2 in Main Ship Channel	Lat 40 32 20 Long 74 01 35	1	Flood			2,000
502	3.42	100 feet east of buey C 9 1/2 in Main Ship Channel	Lat 40 32 20 Long 74 01 35	10	Flood			1,600
503	3.45	100 feet east of buey C 9 1/2 in Main Ship Channel	Lat 40 32 20 Long 74 01 35	20	Flood			700
504	3.55	100 feet east of buey C 11 in Main Ship Channel	Lat 40 34 00 Long 74 02 30	1	Flood			3,600
505	3.57	100 feet east of buey C 11 in Main Ship Channel	Lat 40 34 00 Long 74 02 30	10	Flood			1,900
506	4.00	100 feet east of buey C 11 in Main Ship Channel	Lat 40 34 00 Long 74 02 30	20	Flood			1,500
507	4.10	100 feet east of bell buey, Craven Shoal	Lat 40 35 10 Long 74 02 25	1	Flood			3,800
508	4.12	100 feet east of bell buey, Craven Shoal	Lat 40 35 10 Long 74 02 25	10	Flood			3,200
509	4.15	100 feet east of bell buey, Craven Shoal	Lat 40 35 10 Long 74 02 25	20	Flood			2,100

Number of Bacteria in the water Lower Bay May 19, 1909.

Low water occurred at Governors Island at 2.14 p.m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	No. of Bacteria per C. C.
510	9.30	800 feet west of bell buoy on Craven Shoal	Lat 40 35 10 Long 74 02 40	1	Ebb			6,400
511	9.32	" "	Lat 40 35 10 Long 74 02 40	10	"			4,600
512	9.35	" "	Lat 40 35 10 Long 74 02 40	20	"			3,800
513	10.00	800 feet off South Beach Shore, Staten Island	Lat 40 35 00 Long 74 03 15	1	"			4,200
514	10.12	" "	Lat 40 35 00 Long 74 03 15	10	"			3,600
515	10.32	Off south shore of Staten Island	Lat 40 34 05 Long 74 04 35	1	"			3,200
516	10.36	" " " " " "	Lat 40 34 05 Long 74 04 35	10	"			2,100
517	10.56	" " " " " "	Lat 40 33 10 Long 74 04 35	1	"			2,400
518	11.00	" " " " " "	Lat 40 33 10 Long 74 04 35	10	"			2,000
519	11.22	" " " " " "	Lat 40 32 40 Long 74 05 10	1	"			1,900
520	11.25	" " " " " "	Lat 40 32 40 Long 74 05 10	10	"			1,200
521	11.42	" " " " " "	Lat 40 32 00 Long 74 05 25	1	"			1,200
522	11.45	" " " " " "	Lat 40 32 00 Long 74 05 25	10	"			1,000
523	p.m. 12.10	" " " " " "	Lat 40 31 05 Long 74 05 45	1	"			1,400

Number of Bacteria in the Water. Lower Bay. May 19, 1909.

Low water occurred at Governors Island at 2.14 p.m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	No. of Bacteria per C.C.
524	12.12	Off south shore of Staten Island	Lat 40 31 06 Long 74 05 45	10	Ebb			1,100
525	12.54	100 feet north of Old Orchard Shoal Light	Lat 40 30 45 Long 74 05 56	1	"			1,100
526	12.57	" "	Lat 40 30 45 Long 74 05 56	10	"			700
527	1.16	100 feet north of northern cable buoy	Lat 40 30 05 Long 74 06 15	1	"			1,000
528	1.18	" "	Lat 40 30 05 Long 74 06 15	10	"			800
529	1.20	" "	Lat 40 30 05 Long 74 06 15	20	"			640
530	1.40	100 feet north of southern cable buoy	Lat 40 29 25 Long 74 06 35	1	"			1,200
531	1.42	" "	Lat 40 29 25 Long 74 06 35	10	"			900
532	1.45	" "	Lat 40 29 25 Long 74 06 35	20	"			840
533	1.57	200 feet south of buoy S1W, by wreck	Lat 40 28 35 Long 74 06 45	1	"			950
534	1.59	" "	Lat 40 28 35 Long 74 06 45	10	"			800
535	2.01	" "	Lat 40 28 35 Long 74 06 45	20	"			680
536	2.10	Midway between buoy S1W and Point Comfort Beacon	Lat 40 27 55 Long 74 07 00	1	"			920
537	2.12	" "	Lat 40 27 55 Long 74 07 00	9	"			740

Number of Bacteria in the Water. Lower Bay. May 19, 1909.

Low water occurred at Governors Island at 2.14 p.m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. Water Deg.C	Per-cent land water	No. of Bacteria per C.C.
538	3.05	500 feet south of spar buoy 14, off Seguine Point	Lat 40 30 10 Long 74 10 05	1	Flood			1,100
539	3.07	" "	Lat 40 30 10 Long 74 10 05	10	"			900
540	3.10	" "	Lat 40 30 10 Long 74 10 05	16	"			760
541	3.15	500 feet south of spar buoy N, off Seguine Point	Lat 40 29 55 Long 74 09 40	1	"			980
542	3.17	" "	Lat 40 29 55 Long 74 09 40	10	"			640
543	3.20	" "	Lat 40 29 55 Long 74 09 40	20	"			720

Ex. 95. P. 45.

Number of Bacteria in the Water. East River. May 26, 1909.

High water occurred at Governors Island at 1.21 p.m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	No. of Bacteria per C.C.
844	10.08	20 feet off dock, Lawrence Point, L.I.	Lat 40 47 28 Long 73 54 31	1	Ebb			2,000
845	10.09	" "	Lat 40 47 28 Long 73 54 31	10	"			1,800
846	10.12	1/4 way across East River from Lawrence Point	Lat 40 47 30 Long 73 54 38	1	"			1,800
847	10.14	" "	Lat 40 47 30 Long 73 54 38	10	"			1,800
848	10.20	1/2 way across East River	Lat 40 47 37 Long 73 54 39	1	"			2,100
849	10.22	" " " " "	Lat 40 47 39 Long 73 54 39	10	"			1,800
850	10.24	" " " " "	Lat 40 47 37 Long 73 54 39	20	"			1,500
851	10.30	3/4 way across East River from Lawrence Point	Lat 40 47 44 Long 73 54 40	1	-			2,800
852	10.32	" "	Lat 40 47 44 Long 73 54 40	10	-			2,000
853	10.34	" "	Lat 40 47 44 Long 73 54 40	20	"			1,800
854	10.40	20 feet off dock at Stony Point Bronx	Lat 40 47 50 Long 73 54 41	1	-			2,800
855	10.42	" "	Lat 40 47 50 Long 73 54 41	10	"			2,800
856	10.44	" "	Lat 40 47 50 Long 73 54 41	20	"			1,700

Number of Bacteria in the Water. East River. May 26, 1909.

High water occurred at Governors Island at 1.21 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Per-cent land water	No. of Bacteria per C.C.
887	3.18	80 feet off dock at Lawrence Point, L.I.	Lat 40 47 28 Long 73 54 31	1	Flood			3,400
888	3.19	" " "	Lat 40 47 28 Long 73 54 31	10	"			4,800
889	3.20	1/4 way across East River from Lawrence Point	Lat 40 47 30 Long 73 54 38	1	"			6,000
890	3.22	" " "	Lat 40 47 30 Long 73 54 38	10	"			4,800
891	3.26	1/2 way across East River	Lat 40 47 37 Long 73 54 39	1	"			8,000
892	3.28	" " " " "	Lat 40 47 37 Long 73 54 39	10	"			4,800
893	3.30	" " " " "	Lat 40 47 37 Long 73 54 39	80	"			3,800
894	3.33	3/4 way across East River from Lawrence Point	Lat 40 47 44 Long 73 54 40	1	"			9,000
895	3.37	" " "	Lat 40 47 44 Long 73 54 40	10	"			8,200
896	3.39	" " "	Lat 40 47 44 Long 73 54 40	80	"			6,300
897	3.44	80 feet off dock at Stony Point	Lat 40 47 50 Long 73 54 41	1	"			8,400
898	3.46	" " " " " " "	Lat 40 47 50 Long 73 54 41	10	"			7,800
899	3.49	" " " " " " "	Lat 40 47 50 Long 73 54 41	80	"			5,800

Ex. 98. P. 47.

PEOPLE OF STATE OF NEW YORK vs. STATE OF NEW JERSEY. 24000

Number of Bacteria in the water. Harlem River. May 26. 1909.

High water occurred at Governors Island at 1.21 p.m. The wind was southwest with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Per-cent land water	No. of Bacteria per C.C.
570	11.20	20 feet off dock 118 St. Harlem River	Lat 40 47 43 Long 73 55 48	1	Flood			15,000
571	11.22	" "	Lat 40 47 43 Long 73 55 48	10	"			13,500
572	11.24	" "	Lat 40 47 43 Long 73 55 48	20	"			11,000
573	11.30	Midstream, Harlem River	Lat 40 47 41 Long 73 55 44	1	"			14,000
574	11.32	" " "	Lat 40 47 41 Long 73 55 44	10	"			12,000
575	11.34	" " "	Lat 40 47 41 Long 73 55 44	20	"			10,500
576	11.40	20 feet off dock on Randall Island, Harlem River	Lat 40 47 40 Long 73 55 40	1	"			18,000
577	11.42	" "	Lat 40 47 40 Long 73 55 40	10	"			13,000
578	p.m. 4.08	20 feet off dock foot 118 St. Harlem River	Lat 40 47 43 Long 73 55 48	1	Ebb			9,000
579	4.07	" "	Lat 40 47 43 Long 73 55 48	10	"			8,400
580	4.10	" "	Lat 40 47 43 Long 73 55 48	20	"			6,800
581	4.12	Midstream, Harlem River	Lat 40 47 41 Long 73 55 44	1	"			8,600
582	4.14	" " "	Lat 40 47 41 Long 73 55 44	10	"			7,900
583	4.15	" " "	Lat 40 47 41 Long 73 55 44	20	"			5,300
584	4.18	20 feet off dock on Randall Island, Harlem River	Lat 40 47 40 Long 73 55 40	1	"			8,200

Number of Bacteria in the Water. Harlem River. May 26, 1909.

High water occurred at Governors Island at 1.21 p.m. The wind was southwest with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples			Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "						
585	4.20	20 feet off dock on Randall Island, Harlem River	Lat 40 47 40 Long 73 55 40		10	Ebb			7,400

Ex. 95. P. 49.

Number of Bacteria in the Water. Cross-section Rockaway Inlet. June 29, 1909.
July 1, 1909.

High water occurred at Governors Island at 6.11 p.m. on June 29, 1909. Low water occurred at Governors Island at 12.35 p.m. on July 1, 1909. The wind was northwest with a velocity of 5 miles per hour on June 29th. On July 1, the wind was southwest with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal Current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
	June 29							
586	12.50	50 feet off dock at Rockaway Pt.	Lat 40 34 05 Long 73 53 50	1	Ebb	20.6	16	2,600
587	1.20	1/2 way across Rockaway Inlet	Lat 40 34 15 Long 73 53 55	1	Ebb	20.6	16	2,800
588	1.40	West side of Rockaway Inlet, by gas buoy 2	Lat 40 34 20 Long 73 54 05	1	Ebb	20.6	16	3,200
	July 1							
589	2.45	50 feet off dock at Rockaway Pt.	Lat 40 34 05 Long 73 53 50	1	Flood	19.0	8	1,400
590	3.05	1/2 way across Rockaway Inlet	Lat 40 34 15 Long 73 53 55	1	Flood	19.0	8	1,100
591	3.25	West side of Rockaway Inlet, by gas buoy 2	Lat 40 34 20 Long 73 54 05	1	Flood	19.0	8	1,200

Number of Bacteria in the Water. Beach Channel, Jamaica Bay. June 29, 1909.

High water occurred at Governors Island at 8.11 p.m. The wind was northwest with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
892	2.15	100 feet off Belle Harbor dock Beach Channel	Lat 40 34 55 Long 73 51 05	1	Flood	21.5	16	1,800
893	3.05	100 feet off dock at Seaside Rockaway Beach	Lat 40 35 10 Long 73 49 35	1	Flood	22.5	20	2,700
894	3.35	100 feet above drawbridge, Rockaway Beach, Hammels Station	Lat 40 35 45 Long 73 48 50	1	Flood	23.0	20	3,600
895	5.00	30 feet off dock at clubhouse Bayswater Ave.	Lat 40 36 30 Long 73 46 15	1	Flood	23.0	24	3,800
896	5.20	At bridge head of bat at Edgemere	Lat 40 36 00 Long 73 46 10	1	Flood	27.0	28	4,400

Ex. 95. P. 51.

Number of Bacteria in the Water. Jamaica Bay. June 30, 1909.

Low water occurred at Governors Island at 11.58 a.M. The wind was northwest with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "					
597	7.30	At bridge Norton's Creek, Edgemere	Lat 40 36 00 Long 73 46 10	1	Ebb	27.0	28	8,200
598	7.50	30 off dock foot of Bayswater Ave. Far Rockaway	Lat 40 36 15 Long 73 46 10	1	Ebb	28.0	28	4,200
599	8.30	100 off shore in creek near Averne Station	Lat 40 38 40 Long 73 47 20	1	Ebb	27.0	28	240,000
600	9.50	1000 feet off shore in same creek	Lat 40 36 05 Long 73 47 20	1	Ebb	28.0	28	12,000
601	10.20	Cross Channel near Averne	Lat 40 38 50 Long 73 48 25	1	Ebb	28.0	28	8,000
602	1.10	100 feet off foot Bannister Ave., Averne	Lat 40 38 48 Long 73 48 15	1	Slack	26.0	28	280,000
603	1.40	In creek near foot of Pleasant St., Averne	Lat 40 38 38 Long 73 48 28	1	Flood	27.0	28	22,000
604	2.20	In creek foot of Park Ave. Averne	Lat 40 38 30 Long 73 48 20	1	Flood	27.0	28	30,000
605	3.05	Near foot Pleasant St., Averne	Lat 40 38 38 Long 73 48 10	1	Flood	27.0	28	11,000

Ex. 98. P. 58.

Number of Bacteria in the Water. Jamaica Bay. July 1, 1909.

Low water occurred at Governors Island at 12.38 p.m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	No. of Bacteria per C.C.
			°	'	"					
606	8.88	At mouth Fresh Creek	Lat 40 38 30 Long 73 88 88			1	Ebb	28.0	28	19,000
607	9.10	1/8 way up Fresh Creek	Lat 40 38 80 Long 73 88 80			1	Ebb	28.0	28	12,000
608	9.80	Fresh Creek, just below R. R. crossing	Lat 40 39 18 Long 73 88 48			1	Ebb	28.5	28	16,000
609	10.48	At head of Second Creek	Lat 40 39 08 Long 73 88 00			1	Ebb	28.0	28	1,000,000
610	11.08	At mouth of Second Creek	Lat 40 38 58 Long 73 82 40			1	Ebb	28.8	26	800,000
611	11.38	Jamaica Bay, 800 feet off mouth Second Creek	Lat 40 39 38 Long 73 82 28			1	Ebb	28.8	26	280,000
612	12.00	Jamaica Bay, 800 feet off mouth of Fresh Creek	Lat 40 38 28 Long 73 88 30			1	Ebb	29.6	26	180,000
613	12.80	Jamaica Bay, 800 feet off Sand Bay shore	Lat 40 37 58 Long 73 88 08			1	Ebb	28.0	80	28,000
614	1.20	Creek at Canarsie	Lat 40 38 18 Long 73 94 00			1	Flood	28.0	80	19,000
615	1.48	Jamaica Bay, 100 feet off landing Canarsie	Lat 40 37 40 Long 73 88 18			1	Flood	24.0	80	18,000
616	2.08	Jamaica Bay, 800 feet off bath pool Bergen Beach	Lat 40 37 00 Long 73 88 48			1	Flood	24.0	80	4,800

Number of Bacteria in the Water. Hudson River. July 7, 1909.

High water occurred at Governors Island at 11.16 a.m. The wind was east with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
617	11.40	100 feet off shore Mt. St. Vincent	lat 40 54 40 long 73 54 41	1	Flood	20 1/2	64	6,800
618	12.00	100 feet off shore Mt. St. Vincent	lat 40 54 40 long 73 54 41	8	Flood	20 1/2	64	6,000
619	12.20	200 feet off shore Ludlow Station	lat 40 55 38 long 73 54 30	1	Flood	20 1/2	64	6,200
620	12.30	200 feet off shore Ludlow Station	lat 40 55 38 long 73 54 30	10	Flood	20 1/2	64	5,800
621	12.50	800 feet off shore Federal Sugar Refining Co., Yonkers	lat 40 56 4° long 73 54 28	1	Flood	20 1/2	64	9,800
622	1.00	800 feet off shore Federal Sugar Refining Co., Yonkers	lat 40 56 49 long 73 54 28	10	Flood	20 1/2	64	10,000
623	1.20	200 feet Off Recreation Pier, Yonkers	lat 40 56 18 long 73 54 20	1	Flood	21	64	10,000
624	1.30	200 feet off Recreation Pier, Yonkers	lat 40 56 18 long 73 54 20	20	Flood	21	64	10,000
625	3.20	100 feet off shore Mt. St. Vincent	lat 40 54 40 long 73 54 41	1	Ebb	21	64	13,000
626	3.30	100 feet off shore Mt. St. Vincent	lat 40 54 40 long 73 54 41	8	Ebb	21	64	12,800
627	3.50	200 feet off shore Riverdale	lat 40 54 30 long 73 54 58	1	Ebb	21	64	10,000
628	4.00	200 feet off shore Riverdale	lat 40 54 30 long 73 54 58	10	Ebb	21	64	9,800
629	4.20	800 feet off drawbridge Spuyten Duyvil Creek	lat 40 52 50 long 73 56 25	1	Ebb	21	64	10,800

Number of Bacteria in the Water. Hudson River. July 7, 1909. (Continued.)

Sample No.	Hour p.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "					
630	4.30	200 feet off drawbridge Spuyten Duyvil Creek	Lat 40 52 50 Long 73 55 25	20	Ebb	21	68	8,500
631	4.50	200 feet off shore Inwood Station	Lat 40 52 20 Long 73 55 50	1	Ebb	21	68	9,000
632	5.00	200 feet off shore Inwood Station	Lat 40 52 20 Long 73 55 50	10	Ebb	21	68	9,500

Ex. 95. P. 55.

Number of Bacteria in the Water. Gravesend Bay, Coney Island Creek. July 9, 1909.

High water occurred at Governors Island at 1.01 p.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet below surface				
633	12.30	Gravesend Bay, 200 feet off Marine Basin	Lat 40 36 10 Long 74 00 50	1	Flood	20 1/2	12	3,600
634	1.00	Gravesend Bay, 200 feet off Atlantic Yacht Club	Lat 40 35 35 Long 74 00 00	1	Flood	20 1/2	12	3,800
635	1.30	Coney Island Creek, at mouth	Lat 40 34 45 Long 73 59 20	1	Flood	20 1/2	12	20,000
636	2.15	Coney Island Creek, foot 12 St.	Lat 40 34 55 Long 73 58 55	1	Ebb	21	12	8,500
637	3.10	Coney Island Creek, foot 17 St.	Lat 40 34 55 Long 73 59 05	1	Ebb	21	12	9,000
638	3.40	Gravesend Bay, foot 22 St.	Lat 40 34 50 Long 73 59 35	1	Ebb	22	12	240,000
639	4.30	Gravesend Bay, foot 24 St.	Lat 40 34 45 Long 73 59 40	1	Ebb	21 1/2	12	130,000
640	5.00	Gravesend Bay, 200 feet off Atlantic Yacht Club	Lat 40 35 35 Long 74 00 00	1	Ebb	20 1/2	12	8,000

Number of Bacteria in the Water. Gravesend Bay. July 10, 1909.

High water occurred at Governors Island at 2.09 p.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact: ° ' "		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
641	9.45	End of dock Ulmer Park	Lat 40 35 25 Long 73 59 50		1	Flood	19	12	6,000
642	10.15	End of dock Bay Yacht Club Bath Beach	Lat 40 36 10 Long 74 00 55		1	Flood	19	12	4,500
643	10.40	500 feet off Avon Beach Hotel	Lat 40 36 00 Long 74 00 20		1	Flood	19	12	3,800
644	11.10	100 feet off dock Fort Lowry Hotel	Lat 40 35 50 Long 74 00 10		1	Flood	19	12	3,500
645	11.50	Outer end of Marine Basin	Lat 40 36 10 Long 74 01 05		1	Flood	19	12	3,200
646	12.20	By breakwater north of Coney Island Creek	Lat 40 35 00 Long 73 59 30		1	Flood	19	12	5,800
647	1.05	Foot 22 St. Coney Island	Lat 40 34 50 Long 73 59 35		1	Flood	19	12	140.000

Number of Bacteria in the Water. Sandy Hook Bay, Shrewsbury River, Lower New York Bay.

July 13, 1909.

High water occurred at Governors Island at 8.09 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "					
648	11.40	Sandy Hook Bay, near Shrewsbury	Lat 40 27 50 Long 74 01 25	1	Flood	20 1/2	16	800
649	12.20	Shrewsbury River at Spermaceti Cove	Lat 40 24 55 Long 73 59 35	1	Flood	22	28	1,100
650	1.15	Shrewsbury River at Highland Landing	Lat 40 23 50 Long 73 58 45	1	Flood	23	28	2,400
651	2.05	Navesink River near mouth	Lat 40 22 50 Long 73 59 15	1	Flood	23	28	1,600
652	3.00	Shrewsbury River at Seabright	Lat 40 21 55 Long 73 58 40	1	Flood	25	32	2,800
653	3.45	200 feet off shore Sandy Hook Bay	Lat 40 26 45 Long 73 59 50	1	Flood	20 1/2	20	720
654	4.10	Off west point of Sandy Hook	Lat 40 28 35 Long 74 01 25	1	Flood	20 1/2	20	840
655	4.20	Off west point of Sandy Hook	Lat 40 28 35 Long 74 01 25	1	Flood	20	20	600

Number of Bacteria in the Water. Lower Bay. July 13, 1909.

High water occurred at Governors Island at 8.09 p.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet below surface				
656	4.35	Lower Bay, Main Ship Channel	Lat 40 28 45 Long 74 01 25	1	Flood	20 1/2	16	900
657	4.40	Lower Bay, Main Ship Channel	Lat 40 28 45 Long 74 01 25	40	Flood	20	16	750
658	5.00	Lower Bay, Main Ship Channel	Lat 40 29 50 Long 74 01 00	1	Flood	20 1/2	16	1,100
659	5.10	Lower Bay, Main Ship Channel	Lat 40 29 50 Long 74 01 00	40	Flood	20	16	540

Ex. 98. P. 89.

Number of Bacteria in the Water. Lower Bay. July 14, 1909.

Low water occurred at Governors Island at 11.50 a.m.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
660	9.15	Near bell buoy off Sea Gate Inn	Lat 40 34 15 Long 73 59 50	1	Ebb	19 1/2	16	5,400
661	9.55	" " " " " " "	Lat 40 34 05 Long 73 59 50	1	Ebb	19 1/2	16	6,200
662	10.00	East Bank	Lat 40 32 25 Long 73 59 45	1	Ebb	19 1/2	16	5,600
663	10.30	800 feet from buoy A C 16 in 14 foot channel	Lat 40 31 50 Long 74 00 25	1	Ebb	19 1/2	16	5,200
664	11.00	Romer Shoal south of Ambrose channel	Lat 40 31 20 Long 74 00 35	1	Ebb	19 1/2	16	4,800
665	11.15	Swash Channel	Lat 40 30 40 Long 74 00 50	1	Ebb	19 1/2	16	4,800
666	11.25	" "	Lat 40 30 40 Long 74 00 50	30	Ebb	19	16	2,400
667	11.55	" "	Lat 40 31 20 Long 74 02 15	1	Ebb	19 1/2	16	4,400
668	12.05	" "	Lat 40 31 20 Long 74 02 15	30	Ebb	19	16	3,100
669	1.00	Main Ship Channel	Lat 40 31 20 Long 74 02 30	1	Flood	19 1/2	16	3,900
670	1.10	" " "	Lat 40 31 20 Long 74 02 30	40	Flood	19	16	2,600
671	2.00	500 feet west of West Bank light	Lat 40 32 15 Long 74 02 45	1	Flood	19 1/2	16	4,600
672	2.50	Midway between West Bank light and Elm Tree Beacon	Lat 40 35 05 Long 73 04 10	1	Flood	19 1/2	16	4,800
673	3.30	1000 feet off Elm Tree Beacon	Lat 40 33 45 Long 74 05 30	1	Flood	20	16	4,800

Number of Bacteria in the Water. Harlem River. July 15, 1909.

Low water occurred at Governors Island at 12.46 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Per-cent land water	No. of Bacteria per C.C.
674	12.30	Midstream at E.109 St.	Lat 40 47 23 Long 73 56 07	1	Ebb	21	36	180,000
675	1.05	Midstream at 3 Av.bridge	Lat 40 48 28 Long 73 55 58	1	"	21	36	90,000
676	1.25	Midstream at 155 St.	Lat 40 49 40 Long 73 56 08	1	"	21	36	32,000
677	1.50	Midstream at 207 St.	Lat 40 51 46 Long 73 54 24	1	"	21	36	20,000
678	2.15	Midstream 200 feet east Spuyten Duyvil bridge	Lat 40 52 42 Long 73 55 28	1	"	21	36	12,000
679	3.30	" " "	Lat 40 52 42 Long 73 55 28	1	Flood	21	64	4,800
680	3.45	Midstream at 207 St.bridge	Lat 40 51 46 Long 73 54 24	1	"	21	64	14,000
681	4.10	Midstream at 155 St.bridge	Lat 40 49 40 Long 73 56 03	1	"	21½	36	20,000
682	4.35	Midstream at 3 Av.bridge	Lat 40 48 28 Long 73 55 58	1	"	21½	32	20,000
683	4.50	Midstream at E.109 St.	Lat 40 47 23 Long 73 56 07	1		21	32	40,000

Ex. 98. P. 61.

Number of Bacteria in the Water. Upper Bay. July 16, 1909.

Low water occurred at Governors Island at 1.26 p.m.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet Below Surface				
684	11.30	Midway between Battery and Governors Island	Lat 40 41 50 Long 74 01 00	1	Ebb	20 1/2	28	16,000
685	1.00	3/4 mile north Robbins Reef near buoy G2	Lat 40 40 12 Long 74 03 10	1	Ebb	20 1/2	28	12,000

Ex. 98. P. 62.

Number of Bacteria in the Water. The Narrows. July 16, 1909.

Low water occurred at Governors Island at 1.25 p.m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Per-cent land water	No. of Bacteria per C.C.
686	1.50	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	20.5	28	9,500
687	4.10	" " " "	Lat 40 36 25 Long 74 02 48	1	Flood	20	20	5,200

Ex. 95. P. 63

Number of Bacteria in the Water. Upper Bay. July 16, 1909.

Low water occurred at Governors Island at 1.25 p.m.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	°	'	"	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
688	4.45	3/4 mile north Robbins Reef near buoy G 2	Lat	40	40	12	1	Flood	20	28	8,500
			Long	74	05	10					
689	5.20	Midway between Battery and Governors Island	Let	40	41	50	1	Flood	20	28	11,000
			Long	74	01	00					

Ex. 95. P. 64

Number of Bacteria in the Water. Kill Van Kull. July 17, 1909.

Low water occurred at Governors Island at 8.19 p.m. The wind was east, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. Water deg.C	Percent land water	No. of Bacteria per C.C.
690	9.30	Upper Bay,off Tompkinsville	Lat 40 38 20 Long 74 04 15	1	Ebb	21	28	8,000
691	10.10	Kill van Kull, west end	Lat 40 38 30 Long 74 08 40	1	"	21	28	5,800
692	10.38	Kill van Kull,off Port Richmond	Lat 40 38 35 Long 74 08 00	1	"	21	28	5,400
693	11.00	Bodine Creek, near mouth	Lat 40 38 20 Long 74 07 38	1	"	22	28	6,400

Number of Bacteria in the Water. Upper Bay. July 17, 1909.

Low water occurred at Governors Island at 2.19 p.m. The wind was east with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. Water deg.C	Per cent land water	No. of Bacteria per C.C.
694	11.28	At end of pier foot of 68th St Brooklyn	Lat 40 38 40 Long 74 01 55	1	Ebb	21	28	120,000
695	11.45	By buoy off Governors Bay	Lat 40 39 30 Long 74 01 35	1	"	21	28	90,000
696	12.00	Off Atlantic Docks	Lat 40 41 05 Long 74 00 50	1	"	21	28	26,000
697	p.m. 12.15	800 feet northeast of Ellis Island	Lat 40 41 55 Long 74 02 15	1	"	21	28	22,000

Ex. 98. F. 66

Number of Bacteria in the Water. Upper Bay, Narrows and Lower Bay. July 20, 1909.

High water occurred at Governors Island at 10.21 a.m.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. Water deg.C	Per-cent land water	No. of Bacteria per C.C.
698	11.45 p.m.	Upper Bay just south of Governors Island	Lat 40 40 56 Long 74 01 35	1	Ebb	80½	20	32,000
699	12.25	Upper Bay,800 feet east of Robbins Reef light	Lat 40 39 27 Long 74 03 49	1	"	80½	20	18,000
700	12.45	Narrows,midway between forts	Lat 40 36 28 Long 74 02 48	1	"	80	20	16,000
701	2.50	Lower Bay,800 feet off Hortons Point	Lat 40 34 35 Long 74 00 50	1	"	80	16	8,600

Number of Bacteria in the Water. Lower Bay. July 21, 1909.

High water occurred at Governors Island at 11.01 a.m.

Sample No.	Hour A.M.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg. C	Percent land water	No. of Bacteria per C.C.
702	8.10	Lower Bay, 300 feet off Hortons Pt.	Lat 40 34 35 Long 74 00 50	1	Flood	19.0	12	3,200
703	8.18	" " " " " " "	Lat 40 34 35 Long 74 00 50	20	Flood	19.0	12	1,400
704	9.18	Lower Bay, Ambrose Channel buoy 9	Lat 40 30 18 Long 73 57 40	1	Flood	19.0	0	480
705	9.22	" " " " " "	Lat 40 30 18 Long 73 57 40	40	Flood	19.0	0	240

Ex. 98. P. 60.

Number of Bacteria in the Water. Atlantic Ocean. July 21, 1909.

High water occurred at Governors Island at 11.01 a.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. Water deg.C	Per-cent land water	No. of Bacteria per C.C.
706	12.15	10 miles east of Long Branch, in mud gorge	Lat 40 19 15 Long 73 48 45	1	Flood	19	0	220
707	12.20	" "	Lat 40 19 15 Long 73 48 45	145	"	14	0	40
708	1.00	12 miles east of Long Branch in mud gorge	Lat 40 19 15 Long 73 47 15	1	"	19	0	180
709	1.20	" "	Lat 40 19 15 Long 73 47 15	150	"	14	0	30
710	2.45	On "Oil Spot" off Sandy Hook	Lat 40 27 00 Long 73 58 25	1	Ebb	19	4	440
711	3.00	" " " " " "	Lat 40 27 05 Long 73 58 25	1	"	19	4	280
712	3.30	Off Sandy Hook, at bell buoy 5	Lat 40 28 45 Long 73 59 50	1	"	19	8	1,800
713	3.35	" " " " " " "	Lat 40 26 45 Long 73 59 50	40	"	18	8	740

Ex. 95. P. 69.

Number of Bacteria in the Water. Lower Bay. July 21. 1909.

High water occurred at Governors Island at 11.01 a.m.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet below surface				
714	4.05	Lower Bay, Ambrose Channel buoy 10	lat 40 30 55 Long 73 58 50	1	Ebb	19.0	12	3,200
715	4.10	" " " " " "	lat 40 30 55 Long 73 58 50	40	Ebb	18.0	12	1,400

Number of Bacteria in the Water. The Narrows. July 21, 1909

High water occurred at Governors Island at 11.01 a.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples				Feet below surface	Tidal current	Temp. Water deg.C	Per-cent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "							
716	4.45	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48			1	Ebb	19	12	9,000
717	4.50	" - " "	Lat 40 36 25 Long 74 12 48			40	"	18	12	4,200

Ex. 98. P. 71.

Number of Bacteria in the Water. Upper Bay. July 21, 1909.

High water occurred at Governors Island at 11.01 a.m. The wind was southeast with a velocity of 5 miles per hour.

Sample No.	Hour	Location of Samples		Tidal current	Temp. water deg.C	Per-cent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet below surface			
718	5 25	Upper Bay, 1000 feet off Erie Basin	Lat 40 40 20 Long 74 01 20	1	Ebb	19.5	16	16,000
719	5.30	" "	Lat 40 40 20 Long 74 01 20	20	"	19.5	16	11,500

Ex. 95. P. 72.

Number of Bacteria in the Water. Hudson River, Upper Bay and Lower Bay. July 28, 1909.

High water occurred at Governors Island at 11.51 a.m. The wind was south with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. Water deg.C	Per-cent land water	No. of Bacteria per C.C.
720	10.20	Hudson River, midstream off Gansevoort St.	Lat 40 44 38 Long 74 01 10	1	Flood	20.5	36	14,000
721	10.25	" "	Lat 40 44 38 Long 74 01 10	60	"	19	36	6,400
722	10.45	Hudson River, midstream off Desbrosses St.	Lat 40 43 30 Long 74 01 15	1	"	20.5	36	13,000
723	10.52	" "	Lat 40 43 30 Long 74 01 15	40	"	20	36	7,000
724	11.20	Hudson River, midstream off Pier A.	Lat 40 42 19 Long 74 01 34	1	"	20.5	32	10,500
725	11.28	" "	Lat 40 42 19 Long 74 01 34	40	"	20	32	6,000
726	11.40	Upper Bay, 500 feet east of Liberty Island	Lat 40 41 20 Long 74 02 28	1	"	20	28	8,600
727	11.48 a.m.	" "	Lat 40 41 20 Long 74 02 28	50	"	19.5	28	4,200
728	12.10	Upper Bay, near bell-buoy 22	Lat 40 40 12 Long 74 03 10	1	"	20	28	7,900
729	12.15	" " " " " "	Lat 40 40 12 Long 74 03 10	50	"	19.5	28	3,700
730	12.28	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 50	1	"	20	20	8,000
731	12.30	" "	Lat 40 39 10 Long 74 03 50	60	"	19.5	20	3,700
732	12.50	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	"	20	16	6,400
733	12.56	" " " "	Lat 40 36 25 Long 74 02 48	90	"	19	16	3,600
734	1.15	Lower Bay, 800 feet off Hortons Point	Lat 40 34 35 Long 74 00 50	1	"	20	16	8,600

Number of Bacteria in the Water. Narrows, Upper Bay and Hudson River. July 22, 1909.

Low water occurred at Governors Island at 5.43 p.m. The wind was south with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. Water deg.C	Per-cent land water	No. of Bacteria per C.C.
735	3.05	Narrows, midway between forts	Lat 40 36 25 Long 74 02 48	1	Ebb	20.6	20	8,000
736	3.10	" " " "	Lat 40 36 25 Long 74 02 48	90	"	19	20	4,800
737	3.30	Upper Bay, near Robbins Reef bell-buoy	Lat 40 39 10 Long 74 03 30	1	"	20.6	28	10,500
738	3.37	" "	Lat 40 39 10 Long 74 03 30	60	"	20	28	7,800
739	3.50	Upper Bay, near bell-buoy 28	Lat 40 40 12 Long 74 03 10	1	"	20.6	28	12,000
740	3.55	" " " " " "	Lat 40 40 12 Long 74 03 10	50	"	19.6	28	6,400
741	4.08	Upper Bay, 800 feet east of Liberty Island	Lat 40 41 20 Long 74 02 26	1	"	20.6	28	16,000
742	4.10	" "	Lat 40 41 20 Long 74 02 26	50	"	19.6	28	7,900
743	4.18	Hudson River, midstream off Pier A	Lat 40 42 19 Long 74 01 34	1	"	20.6	32	14,000
744	4.21	" "	Lat 40 42 19 Long 74 01 34	40	"	20	32	8,600
745	4.38	Hudson River, midstream off Desbrosses St.	Lat 40 43 30 Long 74 01 18	1	"	20.6	32	16,000
746	4.40	" "	Lat 40 43 30 Long 74 01 18	40	"	20	32	7,900
747	4.50	Hudson River, midstream off Gansevoort St.	Lat 40 44 38 Long 74 01 10	1	"	20.6	32	13,000
748	4.58	" "	Lat 40 44 38 Long 74 01 10	60	"	19.6	32	6,400

Number of Bacteria in the Water. East River. July 24, 1909.

High water occurred at Governors Island at 12.81 p.m. The wind was north with a velocity of 30 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
749	9.08	800 feet off east dock on Governors Island	Lat 40 41 38 Long 74 00 50	1	Ebb	20.2	28	28,000
750	9.08	" "	Lat 40 41 38 Long 74 00 50	40	"	19.8	28	14,000
751	9.18	800 feet off Pier 38, Brooklyn	Lat 40 40 40 Long 74 01 18	1	"	20.5	28	42,000
752	9.18	" "	Lat 40 40 40 Long 74 01 18	40	"	19.5	28	22,000
753	9.28	800 feet off Erie Basin, in Upper Bay	Lat 40 40 20 Long 74 01 18	1	"	20.1	28	21,000
754	9.30	" "	Lat 40 40 20 Long 74 01 18	30	"	19.8	28	11,000
755	10.00	100 feet off Pier 10, Brooklyn	Lat 40 41 38 Long 74 00 00	1	"	20.5	28	22,000
756	10.08	" "	Lat 40 41 38 Long 74 00 00	40	"	19.8	28	14,000
757	10.28	Foot of Oliver St. Manhattan pier head line	Lat 40 42 30 Long 73 59 50	1	"	21.6	28	124,000
758	10.30	" "	Lat 40 42 30 Long 73 59 50	20	"	20.0	28	48,000
759	10.38	Foot of Corlears St. Manhattan	Lat 40 42 35 Long 73 58 45	1	"	20.8	28	11,000
760	11.00	" "	Lat 40 42 35 Long 73 58 45	20	"	20.0	28	6,500

Number of Bacteria in the Water. Hudson River. July 26, 1909.

High water occurred at Governors Island at 2.58 p.m. Ebb current ran down the river practically all day. The wind was north with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
761	11.00	500 feet off Pier 4, Manhattan	Lat 40 42 25 Long 74 01 10	1	Ebb	20.0	36	16,000
762	11.05	" "	Lat 40 42 25 Long 74 01 10	40	"	19.0	36	9,000
763	11.20	500 feet off foot West 23 St.	Lat 40 45 09 Long 74 00 45	1	"	20.0	52	12,000
764	11.25	" "	Lat 40 45 09 Long 74 00 45	40	"	19.0	52	6,500
765	11.40	500 feet off foot West 59 St.	Lat 40 46 25 Long 73 59 45	1	"	20.0	52	10,000
766	11.43	" "	Lat 40 46 25 Long 73 59 45	40	"	19.0	52	5,400
767	12.00	500 feet off foot West 96 St.	Lat 40 47 50 Long 73 58 40	1	Slack	20.0	52	22,000
768	12.05	" "	Lat 40 47 50 Long 73 58 40	40	"	19.0	52	8,500
769	12.25	500 feet off foot of West 108 St.	Lat 40 48 20 Long 73 58 25	1	"	20.5	64	8,600
770	12.30	" "	Lat 40 48 20 Long 73 58 25	20	"	19.5	64	5,200
771	3.00	At foot of west 155 St. Washington Heights baths	Lat 40 50 00 Long 73 57 05	1	Ebb	21.0	64	7,800
772	3.15	At foot of West 149 St. Manhattan baths	Lat 40 49 45 Long 73 57 15	1	"	21.0	64	8,400
773	3.25	At foot of West 136 St.	Lat 40 49 20 Long 73 57 20	1	"	21.0	64	8,200

Number of Bacteria in the Water. Hudson River. August 19, 1909.

High water occurred at Governors Island at 10.42 a.m. The wind was north with a velocity of 5 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
774	9.15	Midstream opposite Pier 1, Manhattan	Lat 40 42 25 Long 74 01 35	1	Flood	21.5	20	12,000
775	9.20	" "	Lat 40 42 25 Long 74 01 35	50	"	20.5	20	5,000
776	9.40	1000 feet off Pier 17, Manhattan	Lat 40 43 05 Long 74 01 25	1	"	21.5	20	15,000
777	9.45	" "	Lat 40 43 05 Long 74 01 25	20	"	21.0	28	10,000
778	9.50	" "	Lat 40 43 05 Long 74 01 25	40	"	20.5	28	2,500
779	11.00	Midstream, opposite Pier 32 Manhattan	Lat 40 43 40 Long 74 01 15	1	"	21.5	28	24,000
780	11.05	" "	Lat 40 43 40 Long 74 01 15	40	"	21.0	28	8,000
781	11.30	Midstream, opposite Pier 48 Manhattan	Lat 40 44 05 Long 74 01 25	1	"	21.5	28	10,000
782	11.35	" "	Lat 40 44 05 Long 74 01 25	20	"	21.0	28	6,400
783	11.40	" "	Lat 40 44 05 Long 74 01 25	40	"	20.5	28	4,500

Number of Bacteria in the Water. Hudson River. September 7, 1909.

High water occurred at Governors Island at 2.36 p. m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
784	10.20	500 feet off foot of West 42 St.	Lat 40 45 45 Long 74 00 15	1	Ebb	21.0	52	2,500
785	10.25	" " " " " " " "	Lat 40 45 45 Long 74 00 15	35	Ebb	20.5	52	3,000
786	10.55	" " " " " " 72 "	Lat 40 46 55 Long 73 59 25	1	Ebb	21.0	52	7,000
787	10.57	" " " " " " " "	Lat 40 46 55 Long 73 59 25	20	Ebb	20.5	52	8,400
788	11.00	" " " " " " " "	Lat 40 46 55 Long 73 59 25	35	Ebb	20.5	52	9,000
789	11.55	" " " " " " 110 "	Lat 40 48 20 Long 73 58 25	1	Flood	21.0	52	3,000
790	12.00	" " " " " " " "	Lat 40 48 20 Long 73 58 25	40	Flood	20.0	52	6,300
791	12.15	" " " " " " 140 "	Lat 40 49 30 Long 73 57 25	1	Flood	21.0	52	4,200
792	12.17	" " " " " " " "	Lat 40 49 30 Long 73 57 30	20	Flood	20.5	52	2,300
793	12.20	" " " " " " " "	Lat 40 49 30 Long 73 57 30	40	Flood	20.0	52	5,500
794	12.37	500 feet off Fort Washington Pt.	Lat 40 51 10 Long 73 56 50	1	Flood	21.0	52	2,200
795	12.40	" " " " " "	Lat 40 51 10 Long 73 56 50	40	Flood	20.0	52	4,000
796	1.00	500 feet off Inwood bathing beach	Lat 40 52 20 Long 73 55 55	1	Flood	21.0	52	2,100

Number of Bacteria in the Water. Hudson River. Sept. 7, 1909. (Continued.)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
797	1.02	800 feet off Inwood bathing beach	Lat 40 52 20 Long 73 55 55	20	Flood	20.5	82	
798	1.08	" " " " " "	Lat 40 52 20 Long 73 56 57	40	Flood	20.0	82	2,900
799	1.20	800 feet off Spuyten Duyvil drawbridge	Lat 40 52 50 Long 73 56 30	1	Flood	21.0	82	1,500
800	1.25	" " " "	Lat 40 52 50 Long 73 55 30	40	Flood	20.0	82	2,600
801	1.45	" feet off Riverdale station	Lat 40 54 15 Long 73 55 00	1	Flood	21.0	82	2,500
802	1.48	" " " " "	Lat 40 54 15 Long 73 55 00	20	Flood	20.5	82	2,700
803	1.52	" " " " "	Lat 40 54 15 Long 73 55 00	40	Flood	20.0	82	600
804	2.15	800 feet off Federal refinery, Yonkers	Lat 40 55 50 Long 73 54 30	1	Flood	21.0	82	6,700
805	2.19	800 feet " " "	Lat 40 55 50 Long 73 54 30	40	Flood	20.0	82	5,900
806	2.40	800 feet off power plant, northern end of Yonkers	Lat 40 57 00 Long 73 54 10	1	Flood	21.0	82	4,000
807	2.43	" " " " "	Lat 40 57 00 Long 73 54 10	20	Flood	21.0	82	4,700
809	2.48	" " " " "	Lat 40 57 00 Long 73 54 10	35	Flood	20.5	82	7,800

Number of Bacteria in the Water. Passaic River, Newark Bay and Kill van Kull.

September 8, 1909.

High water occurred at Governors Island at 3 21 p.m. The wind was southeast, with a velocity of 10 miles per hour.

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact: ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
809	1.30	Passaic River, near foot of N.J.R.R. Av. Newark	Lat 40 44 49 Long 74 09 55	1	Flood	22.0	52	129,000
810	1.32	" "	Lat 40 44 49 Long 74 09 55	10	"	21.5	52	95,000
811	2.17	Passaic River, 100 feet above P.R.R. freight bridge	Lat 40 44 10 Long 74 09 48	1	"	21.5	40	216,000
812	2.20	" "	Lat 40 44 10 Long 74 09 48	10	"	21.0	40	106,000
813	2.40	Passaic River, near mouth	Lat 40 43 15 Long 74 07 20	1	"	21.0	40	12,000
814	2.43	" "	Lat 40 43 15 Long 74 07 20	10	"	20.5	40	46,000
815	3.00	Newark Bay, near Lehigh Valley R.R. bridge	Lat 40 41 56 Long 74 07 15	1	"	21.0	28	30,000
816	3.02	" "	Lat 40 41 56 Long 74 07 15	10	"	20.5	28	25,000
817	3.23	Newark Bay, near bell-buoy off Centreville	Lat 40 40 15 Long 74 08 10	1	"	21.0	28	2,000
818	3.25	" "	Lat 40 40 15 Long 74 08 10	10	"	20.5	28	1,700
819	3.40	Newark Bay, near C.R.R. of N.J. drawbridge	Lat 40 39 17 Long 74 08 46	1	"	20.5	28	10,000
820	3.42	" "	Lat 40 39 17 Long 74 08 46	15	"	20.5	28	6,000
821	3.45	" "	Lat 40 39 17 Long 74 08 46	30	"	20.0	28	8,000

Number of Bacteria in the Water. Passaic River, Newark Bay and Kill van Kull. Sept. 8, 1909.

(Continued).

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact			Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
602	4.00	Kill van Kull, west end	Lat	40	38 30	1	Flood	20.0	80	1,000
			Long	74	09 45					
603	4.03	" "	Lat	40	38 30	35	Flood	20.0	80	1,800
			Long	74	08 45					
604	4.06	Kill van Kull, opposite Satlers Snug Harbor	Lat	40	39 50	1	"	20.0	80	7,000
			Long	74	06 25					
605	4.09	" "	Lat	40	39 50	20	"	20.0	80	4,400
			Long	74	06 28					
606	4.50	" "	Lat	40	39 50	40	"	20.0	80	9,800
			Long	74	06 28					
607	4.60	Kill van Kull, opposite Constable Hook	Lat	40	39 05	1	"	20.0	80	2,000
			Long	74	08 18					
608	4.45	" "	Lat	40	39 05	40	"	20.0	80	1,000
			Long	74	08 18					

Rm. 95. P. 81.

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2213

Number of Bacteria in the Water. East River. September 9, 1909.

Low water occurred at Governors Island at 10.30 a.m. The wind was southwest with a velocity of 8 miles per hour.

Sample No.	Hour p.m.	Location of Sample — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Per-cent land water	No. of Bacteria per C.C.
829	11.10	Off Battery, midstream	Lat 40 41 50 Long 74 00 55	1	Ebb	20	32	8,000
830	11.12	" " "	Lat 40 41 50 Long 74 00 55	20	"	19.8	32	2,000
831	11.18	" " "	Lat 40 41 50 Long 74 00 55	40	"	19	32	1,000
832	11.30	At Brooklyn Bridge, midstream	Lat 40 42 20 Long 73 59 46	1	"	20	32	2,800
833	11.50	" " " "	Lat 40 42 20 Long 73 59 46	40	"	19	32	1,800
834	11.54	At Williamsburg Bridge, midstream	Lat 40 42 49 Long 73 58 21	1	"	20	32	4,000
835	11.58	" "	Lat 40 42 49 Long 73 58 21	20	"	19.8	32	2,000
836	12.00 p.m.	" "	Lat 40 42 49 Long 73 58 21	40	"	19	32	2,400
837	12.14	Off East 23 St., midstream	Lat 40 44 00 Long 73 58 05	1	"	20	32	2,800
838	12.17	" " " " "	Lat 40 44 00 Long 73 58 05	40	"	19	32	3,800
839	12.25	Off East 49 St., east Channel	Lat 40 45 00 Long 73 57 30	1	Flood	20	32	10,000
840	12.27	" "	Lat 40 45 00 Long 73 57 30	20	"	19	32	7,700
841	12.30	" "	Lat 40 45 00 Long 73 57 30	40	"	19	32	6,000
842	12.42	Off East 70 St., east channel	Lat 40 45 45 Long 73 56 50	1	"	20	32	4,000
843	12.46	" "	Lat 40 45 45 Long 73 56 50	20	"	19	32	2,200

Number of Bacteria in the Water. East River. September 9, 1909.

Low water occurred at Governors Island at 10.38 a.m. The wind was southwest with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
844	12.55	At Hell Gate	Lat 40 46 50 Long 73 56 00	1	Flood	20	32	2,000
845	12.57	" " "	Lat 40 46 50 Long 73 56 00	20	"	19.5	32	1,800
846	1.00	" " "	Lat 40 46 50 Long 73 56 00	40	"	19	32	1,400
847	1.22	Between North and South Brother Islands	Lat 40 47 55 Long 73 53 55	1	"	19.5	28	1,000
848	1.25	" "	Lat 40 47 55 Long 73 53 55	40	"	19	28	600
849	1.50	Off Clausons Point, midstream	Lat 40 46 00 Long 73 50 40	1	"	19	28	1,500
850	1.55	" " " "	Lat 40 48 00 Long 73 50 40	30	"	19	28	2,000
851	2.00	" " " "	Lat 40 48 00 Long 73 50 40	70	"	18.5	28	1,200

Number of Bacteria in the Water. Long Island Sound. Sept. 9, 1909.

Low water occurred at Governors Island at 10.38 a.m. The wind was southwest with a velocity of 5 miles per hour. The flood tide coming up Long Island Sound from the east meets the flood tide coming up the East River near the Stepping Stones Light.

Sample No.	Hour p.m.	Location of Samples			Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c
		Approximate	Exact						
852	2.30	500 feet east of Throgs Neck	Lat 40 48 20 Long 73 47 20		1	Flood	19.0	28	400
853	2.33	" "	Lat 40 48 20 Long 73 47 20		40	"	18.5	28	200
854	2.55	Near Stepping Stones light	Lat 40 49 30 Long 73 46 30		1	"	19.0	28	120
855	2.57	" "	Lat 40 49 30 Long 73 46 30		20	"	18.5	28	300
856	3.00	" "	Lat 40 49 30 Long 73 46 30		40	"	18.5	28	150

Number of Bacteria in the Water. East River. September 10, 1909.

Low water occurred at Governors Island at 11.25 a.m. The wind was southeast with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of Bacteria per C.C.
857	9.55	Hell Gate off East 90 St.	Lat 40 46 30 Long 73 56 30	1	Ebb	19.5	32	1,200
858	9.57	" "	Lat 40 46 30 Long 73 56 30	40	"	19.0	32	1,500
859	10.10	East Channel off East 89 St.	Lat 40 45 25 Long 73 57 30	1	"	19.5	32	9,000
860	10.12	" "	Lat 40 45 25 Long 73 57 30	20	"	19.0	32	9,000
861	10.15	" "	Lat 40 45 25 Long 73 57 30	40	"	19.0	32	7,200
862	10.25	Off East 34 St. Midstream	Lat 40 44 25 Long 73 58 00	1	"	19.5	32	7,500
863	10.28	" "	Lat 40 44 25 Long 73 58 00	40	"	19.0	32	6,000
864	10.35	At Williamsburg bridge, midstream	Lat 40 42 49 Long 73 58 21	1	"	19.5	32	7,000
865	10.37	" "	Lat 40 42 49 Long 73 58 21	20	"	19.0	32	3,300
866	10.40	" "	Lat 40 42 49 Long 73 58 21	40	"	19.0	32	2,800
867	10.47	At Brooklyn bridge, midstream	Lat 40 42 20 Long 73 59 48	1	"	19.5	32	6,500
868	10.50	" "	Lat 40 42 20 Long 73 59 48	40	"	19.0	32	3,000
869	10.55	Off Battery, midstream	Lat 40 41 50 Long 74 00 50	1	"	19.5	32	8,000
870	10.56	" "	Lat 40 41 50 Long 74 00 50	20	"	19.0	32	3,500
871	10.59	" "	Lat 40 41 50 Long 74 00 50	40	"	19.0	32	3,500

Number of Bacteria in the Water. Kill van Kull. September 11, 1909.

Low water occurred at Governors Island at 12.25 p.m. The wind was northwest with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
872	9.40	500 feet off St. George ferry in Upper Bay	Lat 40 38 58 Long 74 04 50	1	Ebb	19.5	28	9,000
873	9.43	" "	Lat 40 38 58 Long 74 04 50	40	"	19.0	28	8,400
874	10.06	Off New Brighton Station, mid-stream	Lat 40 38 57 Long 74 08 25	1	"	19.5	28	10,000
875	10.08	" "	Lat 40 38 57 Long 74 08 25	30	"	19.0	28	9,000
876	10.10	" "	Lat 40 38 57 Long 74 08 25	40	"	19.0	28	6,800
877	10.25	Off Sailors Snug Harbor, mid-stream	Lat 40 38 50 Long 74 06 07	1	"	19.5	28	12,000
878	10.26	" "	Lat 40 38 50 Long 74 06 07	40	"	19.0	28	9,600
879	10.45	Off Port Richmond ferry, mid-stream	Lat 40 38 35 Long 74 07 52	1	"	19.5	28	10,000
880	10.47	" "	Lat 40 38 35 Long 74 07 52	30	"	19.0	28	8,000
881	10.50	" "	Lat 40 38 35 Long 74 07 52	50	"	19.0	28	4,800
882	11.10	West end of Kill	Lat 40 28 38 Long 74 09 30	1	"	19.5	28	8,400
883	11.12	" "	Lat 40 28 38 Long 74 09 30	30	"	19.0	28	7,200

Number of Bacteria in the Water. Lower Bay. September 13, 1909.

Low water occurred at Governors Island at 1.53 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour A.M.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. Water deg.C	Percent land Water	No. of bacteria per c.c.
884	11.00	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 28	1	Ebb	19.5	16	800
885	11.05	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 28	20	Ebb	19.0	16	1,200
886	11.10	Near Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 28	35	Ebb	18.5	16	1,100
887	11.30	In Fourteen Foot Channel near buoy A C 20	Lat 40 32 28 Long 74 00 48	1	Ebb	19.5	16	2,000
888	11.38	In Fourteen Foot Channel near buoy A C 20	Lat 40 32 28 Long 74 00 48	25	Ebb	18.5	16	2,800
	P.M.							
889	12.35	Between Ambrose and Fourteen Foot Channels near buoy A C 10	Lat 40 31 00 Long 73 59 48	1	Ebb	19.5	16	1,800
890	12.40	Between Ambrose and Fourteen Foot Channels near buoy A C 10	Lat 40 31 00 Long 73 59 48	20	Ebb	19.0	16	2,000
891	1.05	About 1000 feet north of buoy A C 4	Lat 40 30 20 Long 73 57 00	1	Ebb	20.0	16	1,400
892	1.10	About 1000 feet north of buoy A C 4	Lat 40 30 20 Long 73 57 00	20	Ebb	19.5	16	1,000
893	1.20	Near Ambrose Channel buoy 4	Lat 40 30 10 Long 73 56 58	1	Ebb	20.0	16	1,700
894	1.25	Near Ambrose Channel buoy 4	Lat 40 30 10 Long 73 56 58	35	Ebb	19.5	16	1,700
895	1.35	Near Ambrose Channel buoy 3	Lat 40 29 55 Long 73 57 08	1	Ebb	20.0	16	1,100

Number of Bacteria in the Water. Lower Bay. September 15, 1909.

Low water occurred at Governors Island at 1.53 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour P.M.	Location of Samples: Approximate	Exact	Feet below surface	Tidal Current	Temp. Water deg.C	Percent land Water	No. of bacteria per c.c.
			° ' "					
896	1.37	Near Ambrose Channel buoy 3	Lat 40 29 58 Long 73 87 05	20	Ebb	19.8	16	900
897	1.47	100 feet north of Sedney Channel buoy 6	Lat 40 29 50 Long 73 87 50	1	Flood	20.0	16	3,000
898	1.80	100 feet north of Sedney Channel buoy 6	Lat 40 29 50 Long 73 87 50	20	Flood	19.0	16	1,400
899	2.10	Between Sedney Channel buoys 6 and 8	Lat 40 29 28 Long 73 87 00	1	Flood	19.8	16	8,000
900	2.18	Between Sedney Channel buoys 6 and 8	Lat 40 29 28 Long 73 87 50	20	Flood	18.8	16	4,800
901	2.28	200 feet south of Sedney Channel buoy 8	Lat 40 29 10 Long 73 87 50	1	Flood	19.5	16	6,800
902	2.38	200 feet south of Sedney Channel buoy 8	Lat 40 29 10 Long 73 87 50	20	Flood	19.0	16	4,400
903	2.60	100 feet south of buoy C B 1 off Sandy Hook	Lat 40 29 18 Long 73 88 18	1	Flood	19.5	16	1,500
904	2.48	100 feet south of buoy C B 1 off Sandy Hook	Lat 40 29 18 Long 73 88 18	20	Flood	19.0	16	1,600
905	2.85	800 feet southeast of buoy C B 3 off Sandy Hook	Lat 40 26 50 Long 73 89 10	1	Flood	19.8	16	1,600
906	3.00	800 feet southeast of buoy C B 3 off Sandy Hook	Lat 40 26 50 Long 73 89 10	20	Flood	19.0	16	1,800

Number of Bacteria in the Water. Lower Bay. September 13. 1909.

Low water occurred at Governors Island at 1.53 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour P.M.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. Water. deg.C	Percent Land Water	No. of bacteria per c.c.
			° ' "					
907	3.30	1000 feet northeast of buoy N 8	Lat 40 28 58 Long 74 01 30	1	Flood	19.8	16	1,900
908	3.36	1000 feet northeast of buoy N 8	Lat 40 28 58 Long 74 01 30	18	Flood	18.8	16	1,700
909	3.58	800 feet southwest of buoy C S 1 near Swash Channel	Lat 40 29 38 Long 74 00 30	1	Flood	19.5	16	2,000
910	4.00	800 feet southwest of buoy C S 1 near Swash Channel	Lat 40 29 38 Long 74 00 30	37	Flood	19.8	16	2,500

Ex. 98. F. 69.

Number of Bacteria in the Water. Lower Bay. September 14, 1909.

Low water occurred at Governors Island at 2.38 p.m. The wind was southeast with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples: Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
911	10.30	Main Ship Channel, 200 feet east of West Bank light	Lat 40 32 20 Long 74 02 30	1	Ebb	19.5	16	450
912	10.35	" "	Lat 40 32 20 Long 74 02 30	35	"	18.5	16	300
913	10.55	Swash Channel, near Main Ship Channel	Lat 40 31 25 Long 74 02 20	1	"	19.5	16	280
914	11.00	" "	Lat 40 31 25 Long 74 02 20	30	"	19.0	16	160
915	11.25	Swash Channel, 300 feet north east of buoy C S 3	Lat 40 30 50 Long 74 01 45	1	"	19.5	16	200
916	11.30	" "	Lat 40 30 50 Long 74 01 45	20	"	19.0	16	120
917	11.47	Swash Channel, 500 feet south of Romer Shoals light	Lat 40 30 45 Long 74 00 45	1	"	19.5	16	150
918	11.50	" "	Lat 40 30 45 Long 74 00 45	30	"	19.0	16	140
919	1.00	Swash Channel, 500 feet south of buoy N S 4	Lat 40 30 00 Long 73 59 45	1	"	19.5	16	300
920	1.05	" "	Lat 40 30 00 Long 73 59 45	30	"	19.0	16	190
921	1.20	Swash Channel, 500 feet north of buoy C S 1	Lat 40 29 45 Long 74 00 30	1	"	19.5	16	-
922	1.25	" "	Lat 40 29 45 Long 74 00 30	25	"	19.0	16	400
923	1.45	Romer Shoals, 500 feet north west of buoy N S 2	Lat 40 29 50 Long 73 59 20	1	"	19.5	16	400
924	1.50	" "	Lat 40 29 50 Long 73 59 20	25	"	19.0	16	150

Number of Bacteria in the Water. Lower Bay. September 14, 1909.

(Continued)

Sample No.	Hour p.m.	Location of Samples: Approximate	Exact o ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
925	2.05	500 feet southeast of buoy A C 9, Ambrose Channel	Lat 40 30 45 Long 73 58 45	1	Ebb	19.5	16	270
926	2.10	500 feet southeast of buoy A C 9, Ambrose Channel	Lat 40 30 45 Long 73 58 45	20	"	19.0	16	250
927	2.15	500 feet northwest of buoy A C 10 Ambrose Channel	Lat 40 31 00 Long 73 58 55	1	"	19.5	16	200
928	2.20	" "	Lat 40 31 00 Long 73 58 55	25	"	19.0	16	250
929	2.45	One-Third of distance between buoy A C 8 and Manhattan Beach	Lat 40 32 05 Long 73 57 40	1	"	19.5	16	130
930	2.50	" "	Lat 40 32 05 Long 73 57 40	20	"	19.0	16	200
931	3.10	Two-Thirds of distance between buoy A C 8 and Manhattan Beach	Lat 40 33 05 Long 73 57 25	1	"	19.5	16	560
932	3.15	" "	Lat 40 33 05 Long 73 57 25	22	"	19.0	16	100

Ex. 95. P. 91.

Number of Bacteria in the Water. Passaic River, Newark Bay and Kill van Kull.

Low water occurred at Governors Island at 8.83 p.m. The wind was southeast with a velocity of 20 miles per hour.

September 15, 1909.

Sample No.	Hour P.M.	Location of Samples		Tidal Current	Temp. water deg.c.	Percent land water	No. of Bacteria per c.c.
		Approximate	Exact	Feet below surface			
933	12.40	Passaic River near foot of N.J.R.R. Ave. Newark	Lat 40 44 49 Long 74 09 55	1	Ebb	22.0	52	230,000
934	12.46	Passaic River near foot of N.J.R.R. Ave. Newark	Lat 40 44 49 Long 74 09 55	10	Ebb	21.5	52	160,000
935	1.05	Passaic River near P.R.R.freight bridge below Newark	Lat 40 44 10 Long 74 09 45	1	Ebb	22.0	52	90,000
936	1.08	Passaic River near P.R.R. freight bridge below Newark	Lat 40 44 10 Long 74 09 45	10	Ebb	21.5	52	40,000
937	1.25	Passaic River near mouth	Lat 40 43 18 Long 74 07 20	1	Ebb	21.0	52	32,000
938	1.30	Passaic River near mouth	Lat 40 43 18 Long 74 07 20	10	Ebb	20.5	52	17,000
939	1.45	Newark Bay, near Lehigh Valley R.R. bridge	Lat 40 41 56 Long 74 07 18	1	Ebb	20.0	32	24,000
940	1.50	Newark Bay, near Lehigh Valley R.R. bridge	Lat 40 41 56 Long 74 07 18	20	Ebb	19.5	32	16,000
941	2.05	Newark Bay near bell-buoy off Centreville	Lat 40 40 18 Long 74 08 10	1	Ebb	20.0	32	12,000
942	2.06	Newark Bay near bell-buoy off Centreville	Lat 40 41 18 Long 74 08 10	20	Ebb	20.0	32	7,400
943	2.15	Newark Bay near C.R.R. of N.J. drawbridge	Lat 40 39 17 Long 74 08 46	1	Ebb	20.0	32	9,000
944	2.16	Newark Bay near C.R.R. of N.J. drawbridge	Lat 40 39 17 Long 74 08 46	20	Ebb	19.0	32	7,200
945	2.25	Kill van Kull west end	Lat 40 38 35 Long 74 08 45	1	Ebb	20.0	28	7,900
946	2.27	Kill van Kull west end	Lat 40 38 35 Long 74 08 45	20	Ebb	19.5	28	6,800
947	2.30	Kill van Kull, west end	Lat 40 38 35 Long 74 08 45	38	Ebb	19.0	28	8,400

Number of Bacteria in the Water. Passaic River, Newark Bay and Kill van Kull. September 15, 1909.

Low water occurred at Governors Island at 2.53 p.m. The wind was southeast with a velocity of 20 miles per hour.

Sample No.	Hour P.M.	Location of Samples		Feet below surface	Tidal Current	Temp. Water deg.C.	Percent land Water	No. of Bacteria per C.C.
		Approximate	Exact					
948	2.43	Kill van Kull off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 28	1	Ebb	20.0	28	8,200
949	2.45	Kill van Kull off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 28	30	Ebb	19.5	28	6,400
950	2.55	Kill van Kull off Constable Hook	Lat 40 39 05 Long 74 05 18	1	Ebb	20.0	28	6,800
951	2.57	Kill van Kull off Constable Hook	Lat 40 39 05 Long 74 05 18	20	Ebb	19.5	28	5,900
952	3.00	Kill van Kull off Constable Hook	Lat 40 39 05 Long 74 05 18	40	Ebb	19.0	28	4,900

Ex. 95. F. 93.

Number of Bacteria in the Water. Arthur Kills. September 16, 1909.

Low water occurred at Governors Island at 3.55 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour A.M.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. Water deg.C.	Percent land water	No. of bacteria per c.c.
			° ' "					
953	11.55	Rahway River 1/2 mile from mouth	Lat 40 35 55 Long 74 12 45	1	Ebb	20.0	64	16,000
954	11.57	Rahway River 1/2 mile from mouth	Lat 40 35 55 Long 74 12 45	8	Ebb	19.8	64	50,000
955	12.25	Arthur Kills opposite mouth of Rahway River	Lat 40 36 35 Long 74 12 15	1	Ebb	20.0	28	23,000
956	12.30	Arthur Kills, opposite mouth of Rahway River	Lat 40 35 35 Long 74 12 15	10	Ebb	19.8	28	20,000
957	1.05	Arthur Kills off Fresh Kills	Lat 40 34 45 Long 74 12 35	1	Ebb	20.0	20	8,000
958	1.10	Arthur Kills off Fresh Kills	Lat 40 34 45 Long 74 12 35	18	Ebb	19.8	28	2,000
959	1.20	Arthur Kills near buoy S A off Smoking Point	Lat 40 33 30 Long 74 13 40	1	Ebb	19.0	20	3,000
960	1.25	Arthur Kills near buoy S A off Smoking Point	Lat 40 33 30 Long 74 13 40	28	Ebb	18.8	28	2,400
961	2.00	Arthur Kills near buoy S 6 north of Rahway River	Lat 40 35 45 Long 74 12 05	1	Ebb	19.8	28	8,000
962	2.05	Arthur Kills near buoy S 6 north of Rahway River	Lat 40 35 45 Long 74 12 05	12	Ebb	19.8	28	8,000
963	2.35	Arthur Kills 1000 feet west of Elizabeth-port drawbridge	Lat 40 39 10 Long 74 11 55	1	Ebb	19.8	28	90,000
964	2.39	Arthur Kills 1000 feet west of Elizabeth-port drawbridge	Lat 40 39 10 Long 74 11 55	12	Ebb	19.0	28	32,000

Number of Bacteria in the Water. Arthur Kille. September 10, 1909.

Low water occurred at Governors Island at 3.28 p.m. The wind was southeast with a velocity of 8 miles per hour.

Sample No.	Hour P.M.	Location of Samples — Approximate	Exact	Feet below surface	Tidal Current	Temp. Water deg.C.	Percent land Water	No. of bacteria per c.c.
			° ' "					
965	2.50	Arthur Kille 1000 feet east of Elizabethport drawbridge	Lat 40 38 50 Long 74 11 45	1	Ebb	19.5	28	7,000
966	2.55	Arthur Kille 1000 feet east of Elizabethport drawbridge	Lat 40 38 50 Long 74 11 45	18	Ebb	19.0	28	3,000
967	3.05	Arthur Kille near buoy 3 4 at east end	Lat 40 38 48 Long 74 10 45	1	Ebb	19.5	28	3,800
968	3.07	Arthur Kille near buoy 3 4 at east end	Lat 40 38 48 Long 74 10 45	18	Ebb	19.0	28	4,800
969	3.17	Midway between Shooters Island and Mariners Harbor	Lat 40 28 35 Long 74 09 30	1	Ebb	19.5	28	8,000
970	3.20	Midway between Shooters Island and Mariners Harbor	Lat 40 28 35 Long 74 09 30	30	Ebb	19.0	28	4,800
971	3.38	West end of Kill van Kull	Lat 40 38 35 Long 74 08 45	1	Ebb	19.5	28	7,000
972	3.40	West end of Kill van Kull	Lat 40 38 35 Long 74 08 45	35	Ebb	19.0	28	4,000

Ex. 98. P. 38.

Number of Bacteria in the Water. Jamaica Bay Sept. 17. 1909

Low water occurredat Governors Island at 4.25 p. m. The wind was northwest with a velocity of 8 miles per hour.

Sample No.	Hour a. m.	Location of Samples		Feet below surface	Tidal current	Temp. Water Deg.C	Percent land water	Number of Bacteria per cc.
		Approximate	Exact ° ' "					
973	10.40	Jamaica Bay near Dead House Creek	Lat 40 34 35 Long 73 54 25	1	Ebb	19.5	20	4,000
974	10.45	" " " "	Lat 40 34 35 Long 73 54 25	15	"	19.0	20	7,200
975	11.00	Jamaica Bay, 200 feet Barren Island	Lat 40 34 40 Long 73 53 00	1	"	19.5	20	3,500
976	11.05	" " " "	Lat 40 34 40 Long 73 53 00	20	"	19.0	20	1,600
977	11.25	Just south of Ruffle Bar	Lat 40 35 40 Long 73 51 35	1	"	19.5	20	4,400
978	11.30	" " " "	Lat 40 35 40 Long 73 51 35	15	"	19.0	20	3,100
979	11.50	About 1 mile off Canarsie breakwater	Lat 40 36 45 Long 73 52 35	1	"	19.5	20	6,100
980	11.55	" " " "	Lat 40 36 45 Long 73 52 35	9	"	19.0	20	3,600
981	12.10	200 feet off Canarsie Light	Lat 40 37 20 Long 73 52 45	1	"	19.5	20	8,000
982	12.12	" " " "	Lat 40 37 20 Long 73 52 45	10	"	19.5	20	3,100
983	1.05	" " " "	Lat 40 37 40 Long 73 53 10	1	"	19.5	20	3,900
984	1.08	" " " "	Lat 40 37 40 Long 73 53 10	8	"	19.5	20	3,900

Number of Bacteria in the Water. Jamaica Bay. September 17, 1909.

Low water occurred at Governors Island at 4.25 p.m. The wind was northwest with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples			Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "	Feet below surface				
985	2.00	1000 feet off mouth of Fresh Creek	Lat 40 38 20 Long 73 52 15	1	Ebb	19.5	20	36,000
986	2.15	1000 feet off mouth of second creek	Lat 40 38 30 Long 73 52 15	1	Ebb	19.5	20	40,000
987	2.30	1/2 mile north of mouth Second creek	Lat 40 38 45 Long 73 51 35	1	Ebb	19.5	20	5,200
988	3.00	1000 feet off shore at Sand Bay	Lat 40 38 05 Long 73 52 40	1	Ebb	19.5	20	16,000

Ex. 95. P. 97.

Number of Bacteria in the Water. Hudson River Sept. 18, 1909.

High water occurredat Governors Island at 10.34 a. m. The wind was southwest with a velocity of 10 miles per hour.

Sample No.	Hour a. m.	Location of Samples. Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	Number of Bacteria per cc.
989	10.05	500 feet off C.R.R. of N.J. ferry Communipaw	Lat 40 42 25 Long 74 02 00	1	Flood	19.5	28	9,600
990	10.08	" " " " "	Lat 40 42 25 Long 74 02 00	40	"	18.5	28	4,200
991	10.15	500 feet off P.R.R. ferry Jersey City	Lat 40 43 00 Long 74 01 55	1	"	19.5	29	9,600
992	10.17	" " " "	Lat 40 43 00 Long 74 01 55	20	"	19.0	28	7,200
993	10.19	" " " "	Lat 40 43 00 Long 74 01 55	40	"	18.5	28	5,300
994	10.35	500 feet off Lackawanna ferry Hoboken	Lat 40 43 40 Long 74 01 50	1	"	19.5	28	12,000
995	10.38	" " " "	Lat 40 43 40 Long 74 01 50	40	"	18.5	28	6,800
996	10.50	500 feet off Stevens Point, Hoboken	Lat 40 44 40 Long 74 01 20	1	"	19.5	28	8,400
997	10.52	" " " "	Lat 40 44 40 Long 74 01 20	20	"	19.0	28	7,900
998	10.55	" " " "	Lat 40 44 40 Long 74 01 20	40	"	18.5	28	4,800
999	11.25	500 feet off west shore ferry Weehawken	Lat 40 46 45 Long 74 00 20	1	"	19.5	28	7,200
1000	11.28	" " " " "	Lat 40 46 45	40	"	19.5	28	4,200

Number of Bacteria in the Water. Lower Bay. September 20, 1909.

Low water occurred at Governors Island at 8.28 p.m. The wind was southeast, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1001	11.58	800 feet southwest of West Bank light	Lat 40 32 10 Long 74 02 40	1	Flood	19.0	8	5,800
1002	11.58	" " " " "	Lat 40 32 10 Long 74 02 40	20	Flood	18.5	8	700
1003	12.20	About 1 mile from West Bank light on line with Port Monmouth	Lat 40 31 28 Long 74 03 00	1	Flood	19.0	8	4,800
1004	12.22	" " " " "	Lat 40 31 28 Long 74 03 00	20	Flood	18.5	8	3,900
1005	1.00	Near white buoy 5 on same line	Lat 40 30 20 Long 73 05 15	1	Flood	19.0	8	2,900
1006	1.05	Near white buoy 5 on same line	Lat 40 30 20 Long 73 05 15	20	Flood	18.5	8	2,200
1007	1.20	Farther south on same line	Lat 40 29 38 Long 74 03 25	1	Flood	19.0	8	2,500
1008	1.25	" " " " "	Lat 40 29 38 Long 74 03 25	25	Flood	18.5	8	3,300
1009	1.40	Farther south on same line, near buoy C C 1	Lat 40 28 38 Long 74 03 15	1	Flood	19.0	8	3,000
1010	1.45	" " " " " "	Lat 40 28 38 Long 74 03 15	25	Flood	18.5	8	1,400
1011	2.00	Farther south on same line	Lat 40 27 40 Long 74 02 40	1	Flood	19.0	8	780
1012	2.03	" " " " "	Lat 40 27 40 Long 74 02 40	20	Flood	18.5	8	900
1013	2.20	About 1 mile off Atlantic Highlands	Lat 40 26 28 Long 74 03 15	1	Flood	18.5	8	500

Number of Bacteria in the Water. Lower Bay. September 20, 1909. (Continued.)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1014	2.28	About 1 mile off Atlantic Highlands	Lat 40 26 25 Long 74 03 15	20	Flood	18.5	8	600
1015	2.40	About 1/2 mile off Atlantic Highlands	Lat 40 25 50 Long 74 03 25	1	Ebb	19.0	8	800
1016	2.43	About 1/2 mile off Atlantic Highlands	Lat 40 25 50 Long 74 03 25	18	Ebb	18.5	8	600
1017	3.40	About 2000 feet west of buoy S 1 W, off Point Comfort	Lat 40 29 00 Long 74 07 50	1	Ebb	19.0	8	500
1018	3.42	" " " " "	Lat 40 29 00 Long 74 07 50	18	Ebb	18.5	8	400
1019	4.00	Nearer Great Kills	Lat 40 29 50 Long 74 07 40	1	Ebb	19.0	8	400
1020	4.02	" " "	Lat 40 29 50 Long 74 07 40	28	Ebb	18.5	8	
1021	4.20	1 1/2 miles south of Great Kills	Lat 40 30 35 Long 74 07 40	1	Ebb	19.0	8	300
1022	4.23	" " " " " "	Lat 40 30 35 Long 74 07 40	15	Ebb	18.5	8	300
1023	4.32	1 mile south of Great Kills	Lat 40 31 10 Long 74 07 45	1	Ebb	19.0	8	550
1024	4.35	1 " " " " "	Lat 40 31 10 Long 74 07 45	10	Ebb	18.5	8	250

Ex. 98. P. 100

Number of Bacteria in the Water. Raritan Bay. September 21, 1909.

Low water occurred at Bedloe Island at 6.20 p.m. The wind was southeast, with a velocity of 8 miles per hour.

Sample No.	Hour a.m.	Location of Sample — Approximate	Exact	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1025	11.48	1900 feet east of buoy 3 S off Seguine Point	Lat 40 30 30 Long 74 01 09	1	Flood	19.0	8	150
1026	11.47	" " " " " "	Lat 40 30 30 Long 74 01 08	20	Flood	18.5	8	110
1027	12.08	Near buoy 3 S in Seguine Channel	Lat 40 30 30 Long 74 11 09	1	Flood	19.0	8	160
1028	12.07	" " " " " "	Lat 40 30 30 Long 74 11 08	25	Flood	18.5	8	160
1029	12.20	1000 feet southeast of Princes Bay light	Lat 40 30 30 Long 74 12 38	1	Flood	19.0	8	190
1030	12.22	" " " " " "	Lat 40 30 30 Long 74 12 38	20	Flood	18.5	8	
1031	12.30	Near red buoy R 6	Lat 40 29 45 Long 74 13 38	1	Flood	19.0	8	180
1032	12.32	" " " "	Lat 40 29 45 Long 74 13 38	25	Flood	18.5	8	200
1033	12.46	Near red buoy R 8	Lat 40 29 05 Long 74 14 30	1	Flood	19.0	8	180
1034	12.47	" " " "	Lat 40 29 05 Long 74 14 30	22	Flood	18.5	8	320
1035	1.00	800 feet north of Great Sedge light	Lat 40 29 15 Long 74 15 15	1	Flood	19.0	8	220
1036	1.05	" " " " " "	Lat 40 29 15 Long 74 15 15	16	Flood	18.5	8	410

Ex. 95. P. 101

Number of Bacteria in the Water. Arthur Kille. September 21, 1909.

Low water occurred at Governors Island at 4.20 p.m. The wind was southeast, with a velocity of 5 miles per hour.

Sample No.	Hour p.m.	Location of Samples	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1037	1.20	Lower end of Kille, 800 feet west of buoy 2	Lat 40 30 10 Long 74 18 40	1	Flood	19.6	0	400
1038	1.25	Lower end of Kille, 800 feet west of buoy 2	Lat 40 30 10 Long 74 18 40	30	Flood	18.8	0	800
1039	1.40	Off Bottenville, 200 feet west of buoy 2 2	Lat 40 30 26 Long 74 18 18	1	Flood	19.0	0	400
1040	1.45	" " " " " "	Lat 40 30 26 Long 74 18 18	45	Flood	18.0	0	600
1041	2.18	Off Smoking Point, 200 feet east of buoy 2 A	Lat 40 33 30 Long 74 13 80	1	Flood	19.0	0	180
1042	2.17	" " " " " "	Lat 40 33 30 Long 74 13 80	30	Flood	18.8	0	
1043	2.35	Off Fresh Kille	Lat 40 34 20 Long 74 12 40	1	Flood	19.0	0	280
1044	2.40	" " "	Lat 40 34 20 Long 74 12 40	29	Flood	18.8	0	280

Number of Bacteria in the water. Kill van Kull, Upper Bay and East River.

September 23, 1909.

High water occurred at Governors Island at 2.14 p.m. The wind was southwest, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1045	11.10	West end of Kill van Kull, near buoy S 2	Lat 40 38 30 Long 74 08 30	1	Flood	18.5	20	18,000
1046	11.12	" " " " " "	Lat 40 38 30 Long 74 08 30	40	Flood	18.0	20	12,000
1047	11.30	Kill van Kull, off Livingston station	Lat 40 38 45 Long 74 06 50	1	Flood	18.5	20	12,000
1048	11.32	" " " "	Lat 40 38 45 Long 74 06 50	20	Flood	18.0	20	9,000
1049	11.35	" " " "	Lat 40 38 45 Long 74 06 50	40	Flood	18.0	20	7,000
1050	12.20	East end of Kill van Kull, off Constable Hook	Lat 40 39 05 Long 74 05 15	1	Flood	18.5	20	8,000
1051	12.25	" " " " "	Lat 40 39 05 Long 74 05 15	40	Flood	18.0	20	3,600
1052	12.50	Upper Bay, near Robbins Reef bell buoy	Lat 40 39 15 Long 74 03 50	1	Flood	18.5	20	6,400
1053	12.52	" " " " "	Lat 40 39 15 Long 74 03 50	20	Flood	18.0	20	5,000
1054	12.55	" " " " "	Lat 40 39 15 Long 74 03 50	40	Flood	18.0	20	3,800
1055	1.05	Upper Bay, near buoy G 2	Lat 40 40 10 Long 74 03 12	1	Flood	18.5	20	5,400
1056	1.07	" " " " "	Lat 40 40 10 Long 74 03 12	40	Flood	18.0	20	

Number of Bacteria in the Water. Kill van Kull. Upper Bay and East River.

(Continued.) September 23, 1909.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1057	1.15	Upper Bay, near buoy S 2, off Liberty Island	Lat 40 41 05 Long 74 02 40	1	Flood	18.5	20	9,000
1058	1.17	" " " " "	Lat 40 41 05 Long 74 02 40	20	Flood	18.0	20	8,400
1059	1.18	" " " " "	Lat 40 41 05 Long 74 02 40	40	Flood	18.0	20	4,500
1060	1.25	East River, between Governors Island and Battery	Lat 40 41 50 Long 74 01 00	1	Flood	18.5	20	10,000
1061	1.27	" " " " "	Lat 40 41 50 Long 74 01 00	40	Flood	18.0	20	7,200
1062	1.35	East River at Brooklyn bridge midstream	Lat 40 42 20 Long 73 59 48	1	Flood	18.5	20	12,000
1063	1.37	" " " "	Lat 40 42 20 Long 73 59 48	20	Flood	18.0	20	
1064	1.40	" " " "	Lat 40 42 20 Long 73 59 48	40	Flood	18.0	20	6,400
1065	1.50	East River at Manhattan bridge Midstream	Lat 40 42 25 Long 73 59 25	1	Flood	18.5	20	12,000
1066	1.52	" " " "	Lat 40 42 25 Long 73 59 25	40	Flood	18.0	20	8,600

Number of Bacteria in the Water. Upper Bay. September 30, 1909.

Low water occurred at Governors Island at 3.17 p.m. The wind was northwest with a velocity of 30 miles per hour.

Sample No.	Hour A.M.	Location of Samples — Approximate	Extra	Feet below surface	Tidal current	Temp. water deg.C.	Percent land water	No. of bacteria per c.c.
1067	10.36	200 feet off Battery	Lat 40 42 10 Long 74 01 10	1	Ebb	18.5	28	9,000
1068	10.38	200 feet off Battery	Lat 40 42 10 Long 74 01 10	40	Ebb	18.0	28	3,600
1069	10.52	200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	1	Ebb	18.5	28	4,200
1070	10.54	200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	20	Ebb	18.0	28	3,000
1071	10.56	200 feet west of Governors Island	Lat 40 41 35 Long 74 01 15	40	Ebb	18.0	28	2,500
1072	11.55	Near Buoy G 2	Lat 40 40 10 Long 74 03 12	1	Ebb	18.5	28	6,400
1073	11.57	Near buoy G 2	Lat 40 40 10 Long 74 03 12	40	Ebb	18.0	28	2,600
1074	12.07	1000 feet west of Robbins Reef light	Lat 40 39 25 Long 74 03 45	1	Ebb	18.5	28	4,800
1075	12.10	1000 feet west of Robbins Reef light	Lat 40 39 25 Long 74 03 45	20	Ebb	18.0	28	3,600

Number of Bacteria in the Water. Kill van Kull. September 30, 1909.

Low water occurred at Governors Island at 3.17 p.m. The wind was northwest with a velocity of 30 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
1076	12.20	East end of Kill	Lat 40 39 05 Long 74 08 15	1	Ebb	18.5	28	4,600
1077	12.22	" "	Lat 40 39 05 Long 74 08 15	20	"	18.0	28	3,800
1078	12.25	" "	Lat 40 39 05 Long 74 08 15	40	"	18.0	28	3,000
1079	12.35	Off Sailors Snug Harbor	Lat 40 38 50 Long 74 06 07	1	"	18.5	28	5,200
1080	12.38	" "	Lat 40 38 50 Long 74 06 07	40	"	18.0	28	2,800
1081	1.05	Off Fort Richmond	Lat 40 38 35 Long 74 07 52	1	"	18.5	28	6,000
1082	1.07	" "	Lat 40 38 35 Long 74 07 52	20	"	18.0	28	3,400
1083	1.09	" "	Lat 40 38 35 Long 74 07 52	40	"	18.0	28	3,040
1084	2.40	West end of Kill	Lat 40 38 30 Long 74 08 30	1	"	18.5	28	6,200
1085	2.43	" "	Lat 40 38 30 Long 74 08 30	40	"	18.0	28	3,600

Number of Bacteria in the Water. East River. October 1, 1909.

High water occurred at Governors Island at 9.21 a.m. The wind was northwest, with a velocity of 40 miles per hour.

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal-current	Temp. water Deg.C	Percent land water	No. of bacteria per C.C.
1086	9.50	500 feet off Pier 3E, Brooklyn	Lat 40 41 10 Long 74 00 30	1	Flood	18.0	28	5,400
1087	9.52	" "	Lat 40 41 10 Long 74 00 30	40	"	18.0	28	3,600
1088	10.00	At Brooklyn Bridge, 500 feet off Brooklyn shore	Lat 40 42 15 Long 73 59 45	1	"	18.0	28	6,000
1089	10.02	" "	Lat 40 42 15 Long 73 59 45	20	"	18.0	28	4,800
1090	10.04	" "	Lat 40 42 15 Long 73 59 45	40	"	18.0	28	3,800
1091	10.16	At Williamsburg Bridge, 500 feet off Brooklyn shore	Lat 40 42 45 Long 73 58 10	1	"	18.0	28	5,800
1092	10.18	" "	Lat 40 42 45 Long 73 58 10	40	"	18.0	28	4,200
1093	10.30	Opposite East 34 St. 500 feet off Brooklyn shore	Lat 40 44 20 Long 73 57 45	1	"	18.0	28	7,200
1094	10.31	Opposite East 34 St. 500 feet off Brooklyn shore	Lat 40 44 20 Long 73 57 45	20	"	18.0	28	4,500
1095	10.33	" "	Lat 40 44 20 Long 73 57 45	40	"	18.0	28	3,500
1096	10.50	At Queensboro bridge, east channel	Lat 40 45 20 Long 73 57 10	1	"	18.0	28	6,000
1097	10.52	" "	Lat 40 45 20 Long 73 57 10	40	"	18.0	28	3,200
1098	11.05	At Hell Gate	Lat 40 46 50 Long 73 56 00	1	"	18.0	28	4,800
1099	11.06	" "	Lat 40 46 50 Long 73 56 00	20	"	18.0	28	3,500
1100	11.08	" "	Lat 40 46 50 Long 73 56 00	40	"	18.0	28	2,000

Number of Bacteria in the Water. Long Island Sound. October 1,1929.

Low water occurred at Governors Island at 4.05 p.m. The wind was northwest with a velocity of 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
1101	1.20	Long Island Sound, near Throgs Neck	Lat 40 48 20 Long 73 47 20	1	Ebb	18.0	28	1,300
1102	1.22	" "	Lat 40 48 20 Long 73 47 20	25	"	18.0	28	800
1103	1.24	" "	Lat 40 48 20 Long 73 47 20	50	"	18.0	28	800

Ex. 98. P. 108

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2700

Number of Bacteria in the Water. East River. October 1, 1909.

Low water occurred at Governors Island at 4.08 p.m. The wind was northwest with a velocity of 40 miles per hour.

Sample No.	Hour P.M.	Location of Samples		Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per C.C.
		Approximate	Exact					
1104	1.50	Between North and South Brothers Islands	Lat 40 47 55 Long 73 53 55	1	Ebb	18.0	89	2,000
1105	1.57	" "	Lat 40 47 55 Long 73 53 55	40	"	18.0	89	1,400

Ex. 98. P. 109

Number of Bacteria in the Water. Harlem River. October 1, 1909.

Low water occurred at Governors Island at 4.05 p.m. The wind was northwest with a velocity of 40 miles per hour.

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria
1106	2.13	Midstream,off East 116 St.	Lat 40 47 35 Long 73 55 50	1	Ebb	18.5	28	10,000
1107	2.15	" "	Lat 40 47 35 Long 73 55 50	20	"	18.5	28	7,200
1108	2.25	Midstream,off East 110 St.	Lat 40 47 20 Long 73 56 05	1	"	18.5	28	12,000
1109	2.27	" "	Lat 40 47 20 Long 73 56 05	20	"	18.5	28	6,800

Number of Bacteria in the Water. East River. October 1, 1909.

Low water occurred at Governors Island at 4.05 p.m. The wind was northwest with a velocity of 40 miles per hour.

Sample No.	Hour P.M.	Location of Samples		Feet below surface	Tidal current	Temp. water deg.C.	Percent land water	No. of bacteria per c.c.
		Approximate	Exact					
1110	2.35	Hell Gate, off East 90 St.	Lat 40 46 40 Long 73 56 20	1	Ebb	18.0	28	5,500
1111	2.36	" "	Lat 40 46 40 Long 73 56 20	20	"	18.0	28	4,800
1112	2.38	" "	Lat 40 46 40 Long 73 56 20	40	"	18.0	28	3,000
1113	2.47	At Queensboro bridge, west channel	Lat 40 45 25 Long 73 57 30	1	"	18.0	28	4,800
1114	2.50	" "	Lat 40 45 25 Long 73 57 30	40	"	18.0	28	3,600
1115	3.08	1000 feet off mouth of Newton Creek	Lat 40 44 10 Long 73 57 55	1	"	18.5	28	9,000
1116	3.10	" "	Lat 40 44 10 Long 73 57 55	30	"	18.0	28	6,800
1117	3.28	1000 feet off Wallabout Bay	Lat 40 42 25 Long 73 58 30	1	"	18.5	28	8,600
1118	3.30	" "	Lat 40 42 25 Long 73 58 30	20	"	18.0	28	7,000
1119	3.32	" "	Lat 40 42 25 Long 73 58 30	40	"	18.0	28	4,800

Number of Bacteria in the Water. East River. October 2, 1909.

High water occurred at Governors Island at 10.17 a.m. The wind was west with a velocity of 20 miles per hour.

Sample No.	Hour a.m.	Location of Samples			Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
		Approximate	Exact	Feet below surface				
1120	9.20	500 feet off Pier 4, Manhattan	Lat 40 42 00 Long 74 00 40	1	Flood	17.0	28	5,100
1121	9.21	" "	Lat 40 42 00 Long 74 00 40	20	"	17.0	28	4,200
1122	9.23	" "	Lat 40 42 00 Long 74 00 40	40	"	17.0	28	3,200
1123	9.35	At Brooklyn Bridge, 500 feet off Manhattan shore	Lat 40 42 25 Long 73 59 55	1	"	17.0	28	5,400
1124	9.37	" "	Lat 40 42 25 Long 73 59 55	40	"	17.0	28	3,800
1125	9.50	At Williamsburg bridge, 500 feet off Manhattan shore	Lat 40 42 50 Long 73 58 30	1	"	17.0	28	4,800
1126	9.52	" "	Lat 40 42 50 Long 73 58 30	20	"	17.0	28	5,200
1127	9.55	" "	Lat 40 42 50 Long 73 58 30	40	"	17.0	28	3,700
1128	10.15	Opposite East 34 St. 500 feet off shore	Lat 40 44 30 Long 73 58 15	1	"	17.0	28	6,400
1129	10.18	" "	Lat 40 44 30 Long 73 58 15	40	"	17.0	28	4,800
1130	10.30	At Queensboro bridge, west channel	Lat 40 45 25 Long 73 57 30	1	"	17.0	28	5,800
1131	10.31	" "	Lat 40 45 25 Long 73 57 30	20	"	17.0	28	5,200
1132	10.33	" "	Lat 40 45 25 Long 73 57 30	40	"	17.0	28	4,100

Number of Bacteria in the Water. East River. October 2, 1939.

(Continued)

Sample No.	Hour a.m.	Location of Samples — Approximate	Exact	Feet below surface	Tidal current	Temp. water deg.C	Percent land water	No. of bacteria per c.c.
1133	10.40	Hell Gate, off East 90 St.	Lat 40 46 30 Long 73 56 20	1	Flood	17.0	28	4,800
1134	10.41	" "	Lat 40 46 30 Long 73 56 20	20	"	17.0	28	4,000
1135	10.43	" "	Lat 40 46 30 Long 73 56 20	40	"	17.0	29	3,600

Ex. 98. P. 113

Number of Bacteria in the Water. Hudson River. October 8, 1909.

High water occurred at Governors Island at 1.00 p.m. The wind was northwest, with a velocity of 10 miles per hour.

Sample No.	Hour a.m.	Location of Samples		Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
		Approximate	Exact ° ' "					
1136	10.35	1/8 way across from foot of West 42 St.	Lat 40 45 50 Long 74 00 20	1	Flood	17.0	82	3,200
1137	10.36	" " " " " "	Lat 40 45 50 Long 74 00 30	20	Flood	17.0	82	2,900
1138	10.37	" " " " " "	Lat 40 45 50 Long 74 00 20	40	Flood	17.0	82	2,100
1139	11.05	2/8 way across from foot of West 42 St.	Lat 40 45 55 Long 74 00 30	1	Flood	17.0	82	3,600
1140	11.07	" " " " " "	Lat 40 45 55 Long 74 00 30	20	Flood	17.0	82	3,200
1141	11.09	" " " " " "	Lat 40 45 55 Long 74 00 30	40	Flood	17.0	82	1,600
1142	11.15	3/4 way across from foot of West 42 St.	Lat 40 46 00 Long 74 00 30	1	Flood	17.0	82	2,000
1143	11.17	" " " " " "	Lat 40 46 00 Long 74 00 30	20	Flood	17.0	82	1,700
1144	11.19	" " " " " "	Lat 40 46 00 Long 74 00 30	40	Flood	17.0	82	1,200
1145	12.15	1/8 way across from foot of West 137 St.	Lat 40 49 30 Long 73 57 35	1	Flood	17.0	82	2,500
1146	12.16	" " " " " "	Lat 40 49 30 Long 73 57 35	20	Flood	17.0	82	2,000
1147	12.18	" " " " " "	Lat 40 49 30 Long 73 57 35	40	Flood	17.0	82	1,400
1148	12.20	2/8 way across from foot of West 137 St.	Lat 40 49 32 Long 73 57 30	1	Flood	17.0	82	2,200

Number of Bacteria in the Water. Hudson River. October 8. 1909. (Continued.)

Sample No.	Hour p.m.	Location of Samples — Approximate	Exact ° ' "	Feet below surface	Tidal current	Temp. water Deg.C	Percent land water	No. of Bacteria per C.C.
1149	12.29	1/8 way across from foot of West 137 St.	Lat 40 49 38 Long 73 57 50	20	Flood	17.0	88	1,600
1150	12.30	" " " " " " "	Lat 40 49 38 Long 73 57 50	40	Flood	17.0	88	1,000
1151	12.40	3/4 " " " " " "	Lat 40 49 40 Long 73 58 08	1	Flood	17.0	88	1,700
1152	12.41	" " " " " " "	Lat 40 49 40 Long 73 58 08	20	Flood	17.0	88	1,800
1153	12.45	" " " " " " "	Lat 40 49 40 Long 73 58 08	38	Flood	17.0	88	900
1154	1.20	800 feet off Inwood	Lat 40 52 20 Long 73 56 56	1	Flood	17.0	88	1,600
1155	1.21	800 feet off Inwood	Lat 40 52 20 Long 73 56 56	20	Flood	17.0	88	1,800
1156	1.23	800 feet off Inwood	Lat 40 52 20 Long 73 56 56	40	Flood	17.0	88	900
1157	1.33	1/2 way across from Inwood	Lat 40 52 28 Long 73 56 08	1	Flood	17.0	88	1,600
1158	1.34	" " " " "	Lat 40 52 28 Long 73 56 08	20	Flood	17.0	88	1,800
1159	1.36	" " " " "	Lat 40 52 28 Long 73 56 08	40	Flood	17.0	88	900
1160	1.46	3/4 way across from Inwood	Lat 40 52 38 Long 73 56 28	1	Flood	17.0	88	1,600
1161	1.47	" " " " "	Lat 40 52 38 Long 73 56 28	20	Flood	17.0	88	1,600
1162	1.49	" " " " "	Lat 40 52 38 Long 73 56 28	38	Flood	17.0	88	700

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 96.

JAMES D. MAHER,
Commissioner.

Average Number of Bacteria in Water in the year 1909.
Summary of Tables 1 to 7. including 1100 Analyses

Location	All Depths and Tides		Depths				Tides			
			Surface		Bottom		Ebb		Flood	
	No. of analyses	Bacteria per c.c.	No. of analyses	Bacteria per c.c.	No. of analyses	Bacteria per c.c.	No. of analyses	Bacteria per c.c.	No. of analyses	Bacteria per c.c.
Upper bay	113	12,500	62	14,600	42	10,300	79	13,800	31	9,300
Hudson river below Spuyten Duyvil	182	6,600	71	8,400	63	4,800	94	8,100	81	5100
Hudson river above Spuyten Duyvil	53	5,100	15	6,300	15	4,400	35	5,200	10	4,700
East river below Hell Gate	119	6,100	41	7,700	41	4,500	55	6,700	61	5,600
East river above Hell Gate	37	3,100	15	3,300	15	2,400	17	1,800	20	4,200
Harlem river	58	15,600	28	22,800	18	8,000	31	16,200	27	15,000
Long Island sound	40	310	19	410	19	190	17	390	23	260
Kill van Kull	80	6,500	30	8,100	28	5,000	49	6,900	31	6000
Newark bay	45	7,400	19	9,000	19	6,300	21	9,000	24	6000
Passaic river at Newark	8	92,000	4	111,000	4	75,000	4	121,000	4	65,000
Arthur Kill	24	5,000	11	5,500	10	4,400	16	7300	7	350
The Narrows	55	4,900	17	8,300	14	2,200	31	6,700	24	2,700
Gravesend bay	15	4,300	8	4,300	—	—	—	—	8	4,300
Lower bay	255	1,600	110	2,100	94	1,100	131	1,600	117	1,500
Jamaica bay	39	8,400	19	9,900	—	—	14	9,800	10	6,400
Rockaway inlet	8	2,900	7	2,300	—	—	5	4,000	3	1,200
Atlantic ocean, 10 miles off Long Branch	4	120	2	200	2	35	—	—	4	120

Complainant's Exhibit No. 96 P.I. James D. Mahon Commissioner

Average Number of Bacteria in Water in the year 1909. 2
without distinction as to Depth or Tide

Location	Number of analyses	Bacteria per C.C.	Samples included in the Averages
Upper bay	113	17,500	1-42, 303-305, 393-399, 684-685, 688-690, 696-699, 715-719, 726-731, 737-742, 749-754, 829-831, 869 873, 1057 1060 1067-1075, 1086-1087 (694 and 695 taken at sewer outfalls and 1056 Lighthouse, are not included)
Hudson river below Spuyten Duyvil	187	6,600	43-46, 364-367, 350-391, 619-620, 679 687, 770 775, 743-746, 761-796 798-800, 989-1020, 1136-1162. (747 Lighthouse)
Hudson river above Spuyten Duyvil	53	5,100	779-783, 617-618, 801-808 (671-678, Taken in sewage fields from Barge yard sewer, not included)
East river below Hell Gate	119	6,100	53-54, 147-166, 725-726, 729-760, 837-846, 857-868, 1067-1068 1088-1100, 1110-1135. (267 and 758 Taken at sewer outfalls and 1003 Lighthouse, are not included)
East river above Hell Gate	37	3,100	81-87, 544-569, 847-863, 1104-1105
Harlem river	58	15,600	701-778, 870-880, 674-683, 1106-1109
Long Island sound	40	310	47-80, 854-856, 1101-1103.
Kill van Kull	80	6,500	167-200, 691-697, 822-828, 874-882, 945-957, 969-970, 1045-1057, 1076-1083.

40 x 8 - 96-8-2

Average Number of Bacteria in Water in the year 1909.
without distinction as to depth or tide

continued.

Location	Number of analyses	Bacteria per C. C.	Samples included in the Averages
Newark Bay	45	7,400	306-327, 335-349, 815-871, 934-944.
Passaic river at Newark	8	97,000	327-330. 809-810. 933-934.
Arthur Kill	24	5,000	958-968. 971-972. 1031-1044 1963 and 964 taken at sewer outfall are not included (104 & 1031 typical)
The Narrows	55	1,900	85-105. 106-126. 400 etc. 1,686-687. 700-716-717. 732-733. 735-736.
Gravesend Bay	15	4,300	633 634. 641 646. (635-640 and 647 taken in or near Coney Island Creek are not included)
Lower Bay	755	1,600	~~414-473, 482-543, 648-673, 701-705; 714-715, 684-932, 1001-1031.~~ (932, 1040 and 1030 typical)
Jamaica Bay	39	8,400	592-598. 613. 615. 616. 975. 988. (599-612 and 614 taken in or near Creeks are not included)
Rockaway Inlet	8	2,400	586-591. 972-974
Atlantic ocean, 1 mile off Long Beach	14	120	706-709

Ex 96 P3

Average Number of Bacteria in Water in the year 1909
Average for Surface and Bottom Samples

Location	Depths					
	Surface			Bottom		
	No. of analyses	Bacteria per C.C.	Samples included in the averages	No. of analyses	Bacteria per C.C.	Samples included in the average
Upper bay	62	14,600	1. 3. 5. 7. 9. 11. 13. 15. 17. 19. 21. 23. 25. 27. 29. 31. 33. 35. 42. 302. 304. 316. 534. 5. 655. 690. 696. 9. 716. 728. 730. 737. 739. 741. 749. 751. 753. 829. 869. 872. 1022. 1055. 1057. 1060. 1067. 1069. 1072. 1074. 1086. (694. Taken at same as 668, not included)	42	10,300	2. 4. 6. 8. 10. 12. 14. 16. 18. 20. 22. 24. 26. 28. 30. 32. 34. 36. 304. 314. 316. 718. 720. 726. 740. 742. 750. 753. 754. 831. 870. 872. 1054. 1056. 1059. 1061. 1068. 1071. 1073. 1075. 1087 (697. Taken at same as 361, not included) (1056 liquefied)
Hudson river above Spuyten Duyvil	71	5,400	43. 46. 344. 347. 370. 373. 376. 378. 382. 383. 385. 391. 394. 397. 400. 353. 354. 358. 362. 364. 369. 373. 377. 381. 383. 385. 619. 629. 631. 730. 733. 734. 742. 746. 757. 761. 762. 765. 767. 769. 771. 3. 774. 776. 779. 781. 784. 786. 789. 796. 798. 800. 799. 959. 991. 994. 996. 999. 1130. 1135. 1142. 1143. 1145. 1151. 1154. 1157. 1160.	68	4,800	366. 369. 373. 374. 376. 381. 384. 389. 390. 398. 396. 399. 3. 252. 347. 361. 364. 368. 37. 376. 380. 384. 387. 391. 630. 632. 634. 734. 736. 740. 744. 748. 762. 764. 766. 768. 770. 774. 778. 780. 782. 788. 790. 793. 795. 798. 800. 996. 998. 998. 998. 1000. 1138. 1141. 1144. 1147. 1150. 1153. 1156. 1159. 1162.
Hudson river above Spuyten Duyvil	15	1,300	239. 242. 244. 249. 248. 249. 256. 257. 266. 269. 261. 617. 621. 623. 625. 629. 801. 804. 806.	15	4,400	231. 234. 238. 242. 244. 247. 250. 254. 258. 260. 263. 618. 622. 624. 626. 628. 803. 804. 808.
East river below Hell Gate	41	7,700	83. 127. 131. 135. 139. 143. 147. 151. 155. 159. 163. 755. 833. 839. 837. 839. 893. 894. 852. 859. 861. 869. 867. 1067. 1065. 1085. 1091. 1093. 1096. 1095. 1110. 1113. 1115. 1117. 1120. 1123. 1125. 1128. 1130. 1133. 759 757 Taken at same as 161 not included)	41	4,500	84. 130. 134. 138. 142. 146. 150. 154. 158. 162. 166. 768. 823. 826. 838. 841. 843. 846. 857. 861. 863. 866. 868. 1064. 1066. 1090. 1092. 1095. 1097. 1100. 1102. 1104. 1106. 1109. 1120. 1124. 1127. 1129. 1132. 1134. 760. 768. Taken at same as 165, not included)

8. 10. 20.

Average Number of Bacteria in Water in the year 1909

continued Averages for Surface and Bottom Samples.

Location	Depth.					
	Surface.			Bottom		
	No of analyses	Bacteria per cc	Samples included in the averages	No of analyses	Bacteria per cc	Samples included in the averages
East river above Hell Gate	15	3,300	31.544.546.547.551.554.557.559 561.564.567.847.849.852.1104.	15	2,400	87.545.547.650.663.536.538.560. 563.666.569.846.851.853.1105.
Harlem river	28	22,600	201.202.206.209.212.215.217.220. 223.226.570.673.574.671.681.684. 674-683.1106.1108.	18	8,000	203.205.208.211.214.216.218.222. 226.228.570.572.573.580.682.684. 1107.1109.
Long Island Sound	19	410	41.49.51.53.54.57.59.6163.65.67.69 71.73.76.771.79.854.1101.	19	190	48.50.52.54.56.58.60.62.64.68.70. 72.1074.78.80.852.1102.
Kill van Kull	30	8,100	167.170.174.178.182.189.187.191.195 (99.691-2.833.834.833.879.817.879. 882.945.948.930.969.1048.1047.1050 1076.1079.1081.1084.	28	5,000	169.173.177.181.185.186.190.194.198 200.823.826.828.876.878.880.883 947.949.952.970.1046.1049.1051. 1078.1080.1083.1084
Newark bay	19	9,000	306.308.311.313.315.317.320.325. 328.341.343.346.398.816.817.819. 939 941 943	19	6,300	307.310.312.314.316.319.322.327. 340.342.345.347.849.816.818.821. 940.942.944.
Passaic river at Newark	4	111,000	327.329.809.983.	4	75,000	328.330 810.984
Arthur Kill	11	5,500	962.967.969.961.963.966.967 971.1037.1039.1041.1043. (963 taken at inner outlet, not included)	10	4,600	936 958.960.962.964 966 968 972.1038.1040.1042.1044. (964, taken at inner outlet, not included) (1042 lighthouse)
The Narrows	17	8,300	84.87.92.97.102.106.108 113 118.123 400 686 3760.716.732. 735.	4	7,200	86.91.96.101.105.109 117.117. 122.126.403.717.733.736 6.60 70

Average Number of Bacteria in Waters in the year 1909.

Continued. Averages for Surface and Bottom Samples.

Location.	Surface			Bottom		
	No of Samples	Bacteria per C.C	Samples included in the average	No of Samples	Bacteria per C.C	Samples included in the average
Gravesend Bay	8	4,200	433-631. 641. 646 (635-631 = 4641 taken in a cross Ferry Channel; water not interchanged)	—	—	No dock samples taken at bottom
Lower Bay	110	2,100	1019. 958. 983. 910. 920. 928. 931. 939. 957. 960. 962. 966. 999. 962. 953. 959. 963. 965. 968. 971. 974. 977. 980. 983. 986. 989. 992. 998 995. 521. 604. 563. 510. 513. 515. 519. 523. 533. 537. 540. 580. 598. 591. 598. 614. 618. 660. 661. 667. 3.701. 2.709. 719. 880. 887. 889. 893. 895. 897. 899. 901. 903. 905. 907. 909. 911. 913. 915. 917. 919. 921. 923. 925. 927. 929. 931. 1001. 1003. 1005. 1007. 1009. 1011. 1013. 1015. 1017. 1019. 1021. 1023. 1025. 1027. 1029. 1031. 1033 (921 Unexplained)	94	1100	1007. 911. 913. 919. 923. 926. 933. 1026. 929. 943. 944. 945. 947. 949. 951. 953. 955. 957. 959. 961. 963. 965. 967. 969. 971. 973. 975. 977. 979. 981. 983. 985. 987. 989. 991. 993. 995. 997. 999. 1001. 1003. 1005. 1007. 1009. 1011. 1013. 1015. 1017. 1019. 1021. 1023. 1025. 1027. 1029. 1031. 1033. (1020 not 1020 Unexplained)
Jamaica Bay	19	9.900	579. 592. 613. 616. 620. 623. 627. 629. 631. 633. 635. 637. 639. 641. 643. 645. 647. 649. 651. 653. 655. 657. 659. 661. 663. 665. 667. 669. 671. 673. 675. 677. 679. 681. 683. 685. 687. 689. 691. 693. 695. 697. 699. 701. 703. 705.

Average Number of Bacteria in water in the year 1909.
Averages for Ebb and Flood Tides

Location	Tides					
	Ebb Currents			Flood Currents		
	No. of analyses	Bacteria per C.C.	Samples included in the averages	No. of analyses	Bacteria per C.C.	Samples included in the averages
Upper bay	79	13,500	1-10, 32-42, 303-2,392, 9,609, 5,612-7, 718, 719, 721-723, 799, 720-819, 821, 761-872, 1047-1075, 7694-8 (taken at same orbit, not included)	31	9,300	13-22, 613, 690, 716, 721, 1002-1004, 1036-1037. (1056 lagoon)
Hudson river below Yonkers Rapids	94	8,100	93, 6, 344, 300, 220-265, 333, 337, 629-633, 742, 8, 761-773, 784-8.	87	5,100	389, 387, 609, 620, 720-725, 774, 788, 799, 796, 798, 800, 919, 1000, 1136-1163. (197 lagoon)
Hudson river above Yonkers Rapids	35	5,200	329-344, 241, 3, 628-634 (625-8, taken in Yonkers sewage; not included)	10	4,700	345-360, 617, 618, 620-8, 801-808 (831-4, taken in Yonkers sewage; not included)
East river below Hell Gate	56	6,700	89-9, 147-166, 754-6, 832-8, 837, 838, 1110, 1119, 759-760. (167-8, taken at same orbit; not included)	61	3,600	137-146, 839, 846, 1062, 1066, 1098, 1100, 1120-1121. (1062 lagoon)
East river above Hell Gate	11	1,800	8-2, 694-696, 1109-1102.	28	4,200	537, 569, 547-823.
Harlem river	31	10,200	715, 725, 878, 886, 879-878, (1106, 1109)	37	15,000	20-214, 870-877, 879, 613.
Long Island sound	17	390	97-56, 77, 80, 1101-1103	23	250	67-76, 730-6.
Kill van Kull	49	6,900	184-200, 69-2,874-883, 940-942, 967-970, 1078-1086	31	6,000	167-183, 821-8, 1090-1091.
Newark Bay	21	9,000	835, 849, 939, 944	24	6,000	300-822, 8-1, 831.
Passaic river at Newark	4	191,000	329, 330, 933-4	11	65,000	822-8, 869, 870.

E-116 P.

continued

Average Number of Bacteria in Water in the year 1909.
Averages for Ebb and Flood Tides

Location	Tides					
	Ebb currents			Flood currents		
	No. of analyses	Bacteria per c.c.	Samples included in the averages	No. of analyses	Bacteria per c.c.	Samples included in the averages.
Arthur Kill	14	7,300	958-962-965-968-971-972. (963-4. Taken at sewer outlet; not included)	7	350	1037-1041-1043-1044. (1042 liquefied)
The Narrows	31	6,700	85-105-400-403-686-700-716-717-735-736.	24	7,700	106-126-687-732-3.
Gravesend Bay	—	—	(636-640. Taken in or near Coney Island Creek and outlet from disposal plant; not included)	8	2,300	633-4-641-6. (633 and 647. Taken in Coney Island creek; not included)
Lower Bay	134	1,600	404-411-428-433-483-485-510-537-660-668-701-714-716-864-896-911-922-1009-1024. (921 and 1020 liquefied)	117	1,500	412-423-434-451-483-509-537-543-648-659-669-673-702-0-897-910-1001-1008-1025-1036. (1130 liquefied)
Jamaica Bay	14	9,800	597-598-975-988. (599-612. Taken in creeks or near large sewer outlets not included)	10	6,400	592-596-613-615-616. (614. Taken in creek not included)
Rockaway Inlet	5	4,000	586-588-973-974.	3	1,200	589-591
Atlantic ocean 10 miles off Long Branch	—	—	No samples taken on the ebb.	4	120	706-709.

E. 46 P.E.

Miscellaneous Analyses not Included Elsewhere.
Bacteria in water in the year 1909.

Location	Number of Analyses	Bacteria per C.C.	Samples included in the Averages
Atlantic ocean near Lower bay.	8	560	424-427. 710-713.
Passaic river below Newark.	16	43,000	323-326. 331-334. 811-814. 935-938
Rahway river	2	34,000	953-954
Bridine Creek	1	6,400	693
Total	27		Note - all samples collected in these regions are included in averages.
Total in previous table	1135		
Total analyses	1162		
Total used in averages	1100+27= 1127.		

Ex vs Pg.

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

VS.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 97.

JAMES D. MAHER,
Commissioner.

Average Amount of Dissolved Oxygen in Water in the year 1909.
Summary of Tables 9 to 15 including 782 Analyses.

Location	All Depths and Tides			Depths						Tides					
				Surface			Bottom			Ebb			Flood		
	No. of Analyses	Average cc per Liter	Average per cent Saturation	No. of Analyses	Average cc per Liter	Average per cent Saturation	No. of Analyses	Average cc per Liter	Average per cent Saturation	No. of Analyses	Average cc per Liter	Average per cent Saturation	No. of Analyses	Average cc per Liter	Average per cent Saturation
Upper bay	80	4.03	68	34	3.80	66	33	3.96	69	48	3.88	65	32	4.26	71
Hudson river below Spuyten Duyvil	97	4.34	73	41	4.17	71	38	4.30	73	29	3.67	64	68	4.63	76
Hudson river above Spuyten Duyvil	32	5.06	88	15	5.11	84	15	4.96	82	10	5.18	83	22	5.01	84
East river below Hell Gate	135	3.82	66	56	3.63	64	56	3.83	66	63	3.53	61	72	4.08	70
East river above Hell Gate	39	4.99	86	19	5.01	86	19	4.99	85	18	5.38	92	21	4.66	80
Harlem river	54	3.21	55	27	3.08	54	27	3.26	57	32	3.11	55	22	3.21	55
Long Island sound	8	5.82	99	3	5.69	98	3	5.92	100	3	5.90	100	5	5.78	99
Kill van Kull	44	4.59	79	28	4.37	78	28	4.74	81	40	4.49	78	24	4.76	82
Newark bay	25	4.31	76	12	4.29	76	13	4.87	77	12	4.21	74	13	4.41	78
Passaic river at Newark	8	0.36	6	4	0.33	6	4	0.40	7	4	0.30	5	4	0.42	7
Arthur Kill	24	1.66	82	12	4.52	80	12	4.81	84	16	4.31	73	8	5.61	100
The Narrows	37	4.70	83	19	4.81	86	17	4.55	80	19	4.16	74	18	5.18	92
Gravesend bay	17	5.00	90	8	4.82	88	—	—	—	—	—	—	10	5.00	90
Lower bay	118	5.40	97	64	5.23	93	53	5.61	100	59	5.29	95	59	5.56	100
Jamaica bay	42	4.00	72	19	3.90	69	—	—	—	16	3.80	67	11	4.20	80
Rockaway inlet	14	5.62	101	6	5.58	101	6	5.60	103	6	5.10	93	6	6.14	111
Atlantic ocean on outside of Long Island	4	6.05	105	2	6.21	111	2	5.89	100	—	—	—	4	6.05	105
Raritan canal	2	0.00	0	2	0.00	0	—	—	—	2	0.00	0	—	—	—
Raritan creek	3	0.00	0	3	0.00	0	—	—	—	—	—	—	3	0.00	0
Delaware canal	1	0.30	6	1	0.30	6	—	—	—	—	—	—	1	0.30	6

Complainants Exhibit No. 97 D1 James Wilson Commissioner.

Average Amount of Dissolved Oxygen in Water in the year 1909.
with distinction as to Depth or Tide.

Location	Number of Analyses	Average c.c. per Litre	Average percent of saturation	Samples included in the Averages
Upper bay	80	4.03	68	191, 342-347, 374-381, 387-398, 411-422, 430-437 499 551, 459-464, 539-541, 574 588, 763-771, 777-789 794-797
Hudson river above Spuyten Duyvil	97	4.34	73	290-293, 423-429, 432-438, 471-510, 699-710, 846-872
Hudson river above Spuyten Duyvil	32	5.05	83	67-78, 278-289 511-518.
East river above Hell Gate	135	3.82	66	143-152 195-199, 242-277, 465 470, 593 596, 647-678, 772-776, 795-810 820-845
East river above Hell Gate	39	4.99	86	111-142, 557-561, 814-815.
Harlem river	54	3.21	55	51-66 99-110, 240-241, 342-341, 816 919
Long Island sound	8	5.82	99	363-366 811-813.
Kill van Kull	64	4.59	79	35-50, 382-385, 532-539, 584-593 633-662, 681-692, 753-761, 786-798

5.97 PB

(Continued) Location	Number of analyses	Average C.C. per liter	Average percent of reduction	Samples included in the averages
Newark bay	25	4.31	76	79-84, 93-98, 525-531, 699-699
Passaic river at Newark	8	0.36	6	87-90, 519-520, 693-699 (Samples taken on ebb & E.E. but tide only included)
Arthur Kill	24	466	82	663-680, 709-719
The Narrows	39	4.70	83	193-194, 311-318, 868-873, 899-900, 919-920, 938-939 991-993
Gravesend bay	17	5.00	90	290-297, 309-309. (298-303 and 310 taken in bay & Coney Is. sewage effluent not included)
Lower bay	118	5.40	97	319-328, 331-341, 901-906, 917-918, 920-921, 990-992. 701-706 (Raritan bay included in lower bay)
Jamaica bay	42	4.09	72	306-312, 330-332-333, 682-698 (316-329 and 334 taken in marsh sewage area effl., not included
Rockaway inlet	14	5.69	101	900-908, 934-939.
Atlantic ocean 10 miles off Long Branch	4	6.05	105	909-910
Raritan canal	2	0.00	0	187-188
Newton creek	3	0.00	0	183-185
Wallabout canal	1	0.30	6	186

2.91 P.J

Average Amount of Dissolved Oxygen in Water in the year 1909.

Continued Averages for Surface and Bottom Samples.

Location	Depths							
	Surface				Bottom			
	No. of Analyses	Average c.c. per Liter	Average per cent Saturation	Samples included in the average	No. of Analyses	Average c.c. per Liter	Average per cent Saturation	Samples included in the average
Upper bay	34	3.80	66	191.349.365.379.377.380.387.389 391.393.395.397.931.936.933.935 949.947.949.959.961.963.939.979 982.743.765.762.770.772.779.783. 790.796.	33	3.96	69	349.347.336.379.387.389.390.392. 394.396.398.933.930.931.937 943.947.951.960.961.969.390.881 978.744.766.769.771.778.781.783. 785.797
Hudson river above Spuyten Duyvil	41	4.17	71	890.893.903.925.930.943.939 937.971.973.977.991.979.981.3 984.986.987.991.999.996.999.301 306.806.809.699.711.719.704.709 906.909.856.855.869.861.860 867.870.	38	4.30	73	891.893.926.932.939.934.936 938.971.979.976.978.980.993 988.990.998.995.999.306.308. 305.898.810.706.709.902.908.710 898.881.939.859.860.864.866 869.871.
Hudson river below Spuyten Duyvil	15	5.11	84	67.69.71.73.75.77.859.880.886.890 896.899.911.914.916	15	4.96	82	63.70.73.76.78.79.879.891.893 895.987.889.816.815.818.
East river above Hell Gate	36	3.63	64	149.148.162.169.171.172.175.177.179 181.198.202.206.207.210.212 215.967.260.268.265.268.270 272.273.965.967.969.982.304 307.309.322.324.327.349.372 379.377.778.779.798.801.803 804.809.840.838.835.867.830 838.838.888.900.903.	36	3.83	66	869.866.868.870.872.874.876.878 880.884.899.900.906.909.911.914 916.919.949.944.947.949.951 954.957.964.965.969.972.974 976.978.980.984.987.989.991 993.996.998.999.901.903 907.910.922.924.926.929 928.934.937.939.942.945
East river above Hell Gate	19	5.01	86	111.113.115.117.119.121.123.125 127.149.131.133.135.137.139.141 887.889.819.	19	4.99	85	110.114.116.118.120.122.124.126 128.180.182.184.186.188.140.142 889.891.815

E.9770

Continued

Location	Depths							
	Surface				Bottom			
	No of analyses	Average cc per litre	Average per unit saturation	Samples included in the averages	No of analyses	Average cc per litre	Average per unit saturation	Samples included in the averages
Harlem river	27	3.04	54	51.53.55.57.59.61.63.65.99.101 103.105.107.109.240.342.344.346 348.350.352.354.356.358.360. 816.818	27	3.26	57	52.54.56.58.60.62.64.66.100.102. 104.106.108.110.241.343.345.347. 349.351.353.355.357.359.361. 817.819
Long Island sound near Throgs Neck	3	5.64	98	562.564.811.	3	5.92	100	563.566.813.
Kill van Kull	28	4.37	78	35.37.39.41.43.45.47.49.382.384 532.534.537.584.587.589.592 655.658.660.681.755.757.760. 786.789.791.794	28	4.74	81	36.38.40.42.44.46.48.50.383.385 533.536.538.586.588.591.593 657.659.663.682.756.759.761. 788.790.793.795.
Newark bay	12	4.29	76	79.81.83.93.95.97.525.527 529.649.651.653.	12	4.37	77	80.82.84.94.96.98.526.528. 531.650.652.654
Passaic river at Newark	4	0.33	6	87.89.519.643.	4	0.40	7	88.90.520.644.
Arthur Kill	12	4.52	80	665.667.669.671.673.675.677.679 747.749.751.753	12	4.81	84	666.668.670.672.674.676.678.680 748.750.752.754
Narrows	17	4.86	86	143.145.147.149.151.153.155.157. 159.161.311.368.371.399.419. 438.442.	17	4.55	80	144.146.148.150.152.154.156.158 160.162.313.370.373.400.420 429.443.
Gravesend bay	8	4.82	88	294.296.304-309 (310 taken near sewer outlet not included)	—	—	—	295.297 only deep samples Water shallow)

Ex 47 P 5

Continued

Location	Depths							
	Surface				Bottom			
	No. of analyses	Average cc per liter	Average percent saturation	Samples included in the averages	No. of analyses	Average cc. per liter	Average per cent saturation	Samples included in the averages
Lower bay	64	5.23	98	314. 321-2. 324. 326. 328. 333. 335. 337. 339. 341. 401. 403. 405. 417. 440. 441. 594. 597. 599. 601. 603. 605. 607. 609. 611. 613. 615. 617. 619. 621. 623. 625. 627. 629. 631. 633. 635. 637. 639. 641. 711. 713. 715. 717. 719. 721. 723. 725. 727. 729. 731. 733. 735. 737. 739. 741. 743. 745.	53	5.61	100	315. 323. 325. 327. 334. 336. 338. 403. 404. 406. 418. 596. 598. 600. 602. 604. 606. 608. 610. 612. 614. 616. 618. 620. 622. 624. 626. 628. 630. 632. 634. 636. 638. 640. 642. 712. 714. 716. 718. 720. 722. 724. 726. 728. 730. 732. 734. 736. 738. 740. 742. 744. 746.
Jamaica bay	14	3.90	69	206. 208. 210. 212. 213. 214. 215. 230. 232-3. 685. 687. 689. 691. 693. 695-698. (216-224. taken in creeks or near mouth of bay. not included)	—	—	—	207. 209. 211. 686. 688. 690. 692. 694 (only bottom samples taken. Water shallow)
Rockaway inlet	6	5.58	101	200. 202. 204. 234. 236. 238. (683. near shore. not included)	6	5.60	103	201. 203. 205. 235. 237. 239 (684. near shore. not included)
Atlantic ocean	2	6.21	111	409. 409	2	5.89	100	408. 410.
Gowanus canal	2	0.00	0	187-188	—	—	—	No deep samples
Newtown creek	3	0.00	0	183-185	—	—	—	No deep samples.
Welldone canal	1	0.30	6	186	—	—	—	No deep samples.

E. 97 P6

Average Amount of Dissolved Oxygen in Water in the year 1909.
Averages for Ebb and Flood Tides

Location	Tides							
	Ebb Currents				Flood Currents			
	No. of analyses	Average c.c. per Liter	Average per cent saturation	Samples included in the averages	No. of analyses	Average c.c. per Liter	Average per cent saturation	Samples included in the averages
Upper bay	48	3.88	65	191.362-7.380-1.387-394.395-398 421-2, 444-451 529-561.570 573 727-735.	32	4.26	71	374-379.430 437.459-466. 762-771. 796-797
Harlem river below Spuyten Duyvil	29	3.67	66	290-293.452-458 471-483 494-498	68	4.63	76	423-429.484-493.499-510 699-710 846-872.
Harlem river above Spuyten Duyvil	10	5.13	88	47-72 286 289	22	5.01	84	73-78. 278-285. 511-518
East river below Hell Gate	63	3.53	61	173-182.242-259.542-548. 547-578. 820-829.	72	4.08	70	143-172.198-9.260 277 465 470 549-556. 732-4. 798-810 830 845
East river above Hell Gate	18	5.38	92	117 122.133-142. 814-815	21	4.66	80	111-116 123-132. 557-561
Harlem river	32	3.21	55	51-60 105-110.240-1. 342-351 816-819	22	3.21	55	61-66 99-104 352-361.
Long Island sound near Throgs Neck	3	5.90	100	811-813	5	5.78	99	562-567
Kill van Kull	40	4.49	78	35-40. 382-385. 584-593. 655-662. 681-2. 786-795	24	4.76	82	40-50. 539-538. 755-761.
Newark	12	4.21	74	79-84. 649-654.	13	4.41	78	93-98. 525-531.

697 P 7

Continued

Location	Tides							
	Ebb currents				Flood currents			
	No. of analyses	Average c.c. per liter	Average percent saturation	Samples included in the average	No. of analyses	Average c.c. per liter	Average per cent saturation	Samples included in the average.
Passaic river at Newark	4	0.80	5	87-8, 643-4.	4	0.42	7	89-90, 519-520
Arthur Kill	16	4.31	73	665-680.	8	5.61	100	747-754
Narrows	19	4.16	74	153-162, 368-370, 399-400, 419-420, 992-3.	18	5.18	92.	142-152, 311-313, 371-373, 438-9.
Gravesend bay	—	—	—	(299-303 taken in Coney Island creek and near mouth of disposal plant, not included)	10	5.00	90	294-297, 304-309 (298 and 310, taken near mouth of disposal plant, not included).
Lower bay	59	5.29	95	328-336, 401-2, 417-418, 599-606, 621-642, 725-734.	59	5.56	100	314-315, 321-327, 387-391, 402-406, 440-1, 607-620, 711-724, 735-
Jamaica bay	16	3.80	67	214, 215, 688-699. (216-219 and 228-229, taken in creeks or near sewer outlets, not included)	11	4.20	80	206-213, 220, 232-3, (220-222, taken near sewer outlets not included)
Rockaway inlet	6	5.10	93	200-205. (683-684, taken near shore, not included)	6	6.14	111	234-239
Hempstead creek	—	—	—	No samples taken on the ebb.	4	6.05	105	407-410.
Jamaica creek	2	0.00	0	187-8	—	—	—	No samples taken on the flood
Upper bay creek	—	—	—	No samples taken on the ebb	3	0.00	0	193-195
Hackensack creek	—	—	—	No samples taken on the ebb.	1	0.00	6	196

Miscellaneous Averages not Included Elsewhere
Dissolved Oxygen in the year 1909

Location	Number of analyses	Average c.c. per litre	Average per cent of saturation	Samples included in the averages
Atlantic ocean - N Sandy Hook	6	6.20	112.	411 - 416
Passaic river below Newark	12	2.36	41	85-86, 91-92, 521-524, 645, 648.
Shrewsbury river	5	5.76	105	316-320
Rahway river	2	3.54	59	663-664
Robins creek	1	3.96	70	326
Newarus bay	2	1.55	29	189-190
Wallabout bay	6	1.65	29	192-197
Total	34			Note - All samples collected in these regions are included in averages
Total - previous table	804			
Total analyses	838			Note - The series begins with sample No. 35
Total used in averages	782 + 34 = 816			Ex. 97 P9

THE PEOPLE OF THE STATE OF NEW YORK,
COMPLAINANTS,

vs.

STATE OF NEW JERSEY ET AL.

COMPLAINANTS' EXHIBIT No. 98.

JAMES D. MAHER,
Commissioner.

Examination of Deposits from the Harbor Bottom, East River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
20	Nov.18 1909.	25 feet off pier at E.6th St.	Lat 40 43 18 Long 73 59 25	40	Black	H_2S	Sludge	Polluted
21	"	In slip between Piers 17-18	Lat 40 42 21 Long 74 00 08	30	"	"	"	"
22	"	In slip between Piers 15-16	Lat 40 42 19 Long 74 00 12	30	"	"	"	"
23	"	In slip between Piers 48-49	Lat 40 42 54 Long 73 58 33	30	"	"	"	"
24	"	In slip between Piers 18-19	Lat 40 42 23 Long 74 00 07	30	"	"	"	"
25	"	100 feet from abutment Williamsburg Bridge, Manhattan side	Lat 40 42 51 Long 73 59 29	40	"	"	"	"
26	"	In slip between Piers 11-12	Lat 40 42 13 Long 74 00 22	35	"	"	"	"
27	"	In slip between Piers 30-31	Lat 40 42 32 Long 73 59 36	35	"	"	"	"
28	"	In slip between Piers 14-15	Lat 40 42 18 Long 74 00 15	35	"	"	"	"
29	"	In slip between Piers 34-35	Lat 40 42 35 Long 73 59 21	35	"	"	"	"
30	"	100 feet off center line bulkhead between Piers 18-19	Lat 40 42 24 Long 74 00 08	40	"	Oily H_2S	"	"
31	"	25 feet off bulkhead just east of E. 12th St.	Lat 40 43 31 Long 73 58 21	40	"	"	"	"
32	"	100 feet off pier, Bradley Contracting Co., East River, Manhattan	Lat 40 42 39 Long 73 58 27	35	"	Oily	Sludge Clay	
33	"	In slip just east of E.13th St.	Lat 40 43 35 Long 73 58 23	40	"	Oily H_2S	Sludge	"
34	"	In slip between Piers 12-13	Lat 40 42 15 Long 74 00 19	40	"	H_2S	"	"
35	"	25 feet off E. 9th St. Pier	Lat 40 43 20 Long 73 58 22	40	"	Oily H_2S	"	"

Ex. 98. P. 1.

Complainants Ex hibit No. 98.
James D. Maher
Commissioner

PEOPLE OF STATE OF NEW YORK VS STATE OF NEW JERSEY. 2789

58-73

Examination of Deposits from the Harbor Bottom, East River.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
36	Nov. 16, 1908	In slip between Piers 32-33	Lat 40 42 33 Long 73 59 29	35	Black	Oily H_2S	Sludge	Polluted
37	"	In slip between Piers 27-28	Lat 40 42 31 Long 73 59 44	35			Sludge Clay	"
38	"	In slip between Piers 33-34	Lat 40 42 34 Long 73 59 25	35	Black	Oily H_2S	Sludge	"
39	"	In slip between Piers 45-46	Lat 40 42 47 Long 73 58 32	35	"	"	"	"
40	"	25 feet off bulkhead E.10th St.	Lat 40 43 27 Long 73 58 24	40	"	Oily tarry	"	"
41	"	In slip between Piers 28-29	Lat 40 42 32 Long 73 59 41	35	"	Oily	"	"
42	"	In slip between Piers 29-30	Lat 40 42 32 Long 73 58 41	35				"

Ex. 98. P. 2.

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Location of Samples: Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
43	Dec.5, 1908.	50 feet off east pier, Governors Island	Lat 40 41 30 Long 74 00 48	40	Black	Oily	Sludge Sand	Polluted
44	"	300 feet southeast of Ellis Island	Lat 40 41 50 Long 74 02 20	20	Gray brown	None	Clay	Doubtful
48	"	300 feet off Owl Head	Lat 40 38 20 Long 74 02 19	40	Grayish brown	"	"	"
49	"	About midway between Robbins Reef and Liberty Island	Lat 40 40 18 Long 74 03 22	30	Brown	"	"	"
50	"	100 feet off black spar buoy south of Black Tom channel	Lat 40 41 04 Long 74 02 40	40	-	-	"	Unpolluted
51	Dec.10, 1908	Midway between Battery and Governors Island	Lat 40 41 53 Long 74 01 04	40	-	-	Sludge Mud	Doubtful
52	"	500 feet northwest of Governors Island light	Lat 40 41 38 Long 74 01 13	50	-	-	Sludge Clay	Polluted
53	"	50 feet off Governors Island	Lat 40 41 30 Long 74 01 15	40	-	-	"	Doubtful
54	"	100 feet west of Governors Island	Lat 40 41 18 Long 74 01 27	35	-	-	"	Polluted
55	"	2500 feet west of Governors Island	Lat 40 41 07 Long 74 02 09	70	-	-	"	Doubtful
56	"	3000 feet southwest of Governors Island	Lat 40 40 52 Long 74 02 08	70	-	-	"	"
57	"	3/4 mile off Erie Basin	Lat 40 40 30 Long 74 01 52	25	-	-	Sludge Clay-sand	"
58	"	100 feet southwest of Governors Island	Lat 40 41 10 Long 74 01 36	30	-	-	"	"
59	"	500 feet southwest of Governors Island	Lat 40 40 58 Long 74 01 35	40	-	-	Sludge Clay	Polluted
60	"	200 feet east of bell buoy, Governors Island	Lat 40 40 58 Long 74 01 48	40	-	-	"	Doubtful
61	Nov.28, 1908	75 feet southwest of Aquarium	Lat 40 42 11 Long 74 01 03	30	Black	Oily	"	"

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact			Depth of water (feet)	Color	Odor	Consistency	Opinion
62	Nov.30, 1908	50 feet outside slip between Piers 23-24, Brooklyn	Lat	40	41 32	40	-	-	Core Sand	Doubtful
			Long	74	00 16					
63	"	150 feet outside slip between Piers 24-26, Brooklyn	Lat	40	41 28	40	-	-	Core Sludge	Polluted
			Long	74	00 20					

Ex. 98. P. 4

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
64	Dec.18, 1908	Midstream opposite Pier A, Hudson River	Lat 40 42 19 Long 74 01 34	50	-	-	Sludge Gravel	Doubtful
66	"	1800 feet off Pier A, Hudson River	Lat 40 42 19 Long 74 01 31	50	-	-	Ashes Gravel	"
67	"	3000 feet off Pier A, Hudson River	Lat 40 42 20 Long 74 01 47	50	-	-	Sludge Clay	Polluted
68	"	Hudson River off Pier A	Lat 40 42 15 Long 74 01 08	50	-	-	"	Doubtful
69	"	300 feet off shore C.R.R. N.J. clock on line with Pier A, N.R.	Lat 40 42 26 Long 74 02 00	25	Black	-	"	Polluted

Examination of Deposits from the Harbor Bottom. Upper Bay.

Examination No.	Date of Collection	Location of Sample: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
70	Dec.15, 1909	8000 feet east of Ellis Island	Lat 40 42 03 Long 74 01 57	40	Black	-	Sludge Clay	Doubtful
71	"	8000 feet northeast of Ellis Island	Lat 40 42 11 Long 74 01 59	40	-	-	"	Polluted
72	"	2800 feet east of Ellis Island	Lat 40 42 00 Long 74 01 56	40	-	-	"	Doubtful
73	"	" " " " " " "	Lat 40 41 52 Long 74 01 53	40	-	-	"	Polluted
74	"	1000 feet southeast of Communipaw	Lat 40 42 13 Long 74 01 54	40	-	-	"	"
75	"	2800 feet southeast of Ellis Island	Lat 40 41 41 Long 74 01 52	35	-	-	"	"
76	"	3000 feet southeast of Ellis Island	Lat 40 41 25 Long 74 01 52	30	-	-	"	Doubtful
77	"	3800 feet southeast of Ellis Island	Lat 40 41 37 Long 74 01 38	110	Black	-	"	Polluted
78	"	800 feet west of Governors Island	Lat 40 41 18 Long 74 01 38	30	-	-	"	"
79	"	100 feet off buoy U.S.off Liberty Island	Lat 40 41 18 Long 74 02 37	60	-	-	"	"
80	"	900 feet south of red gas buoy S. Black Tom channel	Lat 40 40 58 Long 74 02 44	50	-	-	"	Doubtful
81	"	South edge Black Tom channel	Lat 40 41 12 Long 74 02 50	18	Brown	-	Clay	"
82	Dec.16, 1909	800 feet off Battery	Lat 40 42 07 Long 74 01 07	30	-	-	Sludge Gravel-clay	Polluted "
83	"	Halfway across Hudson River opposite Pier A	Lat 40 42 19 Long 74 01 54	50	-	-	Sludge Clay	"
84	"	1/3 way across Hudson River opposite Pier A	Lat 40 42 29 Long 74 01 56	50	-	-	"	"
85	"	3000 feet east of Ellis Island	Lat 40 41 54 Long 74 01 37	40	Brown	-	"	"
86	"	8000 feet off C.R.R.of N.J. pier	Lat 40 42 17 Long 74 01 39	40	Black	-	Sludge	Doubtful

Ex. 98. P. 6.

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 2694

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
87	Dec.16, 1908	1000 feet off C.R.R.of N.J. pier	Lat 40 41 19 Long 74 01 45	48	Black	-	Sludge	Doubtful
88	"	800 feet off Battery	Lat 40 42 07 Long 74 01 11	30	-	-	"	Polluted
89	"	150 feet off Battery	Lat 40 42 09 Long 74 01 05	30	-	-	"	"
90	"	2100 feet off C.R.R.of N.J. pier	Lat 40 42 12 Long 74 01 38	30	-	-	"	"
91	"	1800 feet off C.R.R.of N.J. pier	Lat 40 42 13 Long 74 01 49	30	-	-	Sludge Gravel	"
92	"	600 feet east of Ellis Island	Lat 40 41 57 Long 74 02 06	30	-	-	Sludge	"
93	"	600 feet east of Ellis Island	Lat 40 41 50 Long 74 02 10	28	-	-	"	"
94	Dec.17, 1908	600 feet east of Liberty Island	Lat 40 41 21 Long 74 02 24	40	Black	Oily	"	"
95	"	2800 feet east of Liberty Island	Lat 40 41 25 Long 74 00 08	40	Brown	-	Sludge Clay	"
96	"	1800 feet east of Governors Island	Lat 40 41 25 Long 74 01 22	70	-	-	"	"
97	"	600 feet east of Liberty Island	Lat 40 41 24 Long 74 02 30	40	-	-	"	"
98	"	1/2 mile southeast of Battery	Lat 40 41 22 Long 74 01 24	40	Black	Oily	Sludge	"
99	"	" " " " "	Lat 40 41 30 Long 74 01 29	40	"	"	"	"
100	Dec.21, 1908	800 feet northwest of Governors Island	Lat 40 41 33 Long 74 01 24	60	-	-	Sludge Clay	"
101	"	800 feet northwest of Governors Island	Lat 40 41 38 Long 74 01 20	60	Black brown	Oily	"	"
102	"	800 feet northwest of Governors Island	Lat 40 41 38 Long 74 01 28	60	-	-	"	"

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Location of Samples: Exact ° ' "	Depth of Water (feet)	Color	Odor	Consistency	Opinion
103	Dec.21, 1908	3000 feet east of Ellis Island	Lat 40 41 57 Long 74 01 46	40	-	-	Sludge Clay	Polluted
104	"	300 feet north of Liberty Island docks	Lat 40 41 27 Long 74 02 35	15	-	-	Clay	Doubtful
105	"	500 feet south of Ellis Island	Lat 40 41 49 Long 74 02 20	10	-	-	"	Polluted
106	"	On line Liberty Island to Ellis Island halfway	Lat 40 41 37 Long 74 02 30	8	-	-	"	"
107	"	600 feet south of east dock of Ellis Island	Lat 40 41 50 Long 74 02 21	15	-	-	"	"
108	"	300 feet east of Ellis Island	Lat 40 41 59 Long 74 02 15	15	-	-	"	"
109	"	500 feet north of Ellis Island	Lat 40 42 07 Long 74 02 16	10	-	-	Sludge Clay	"
110	"	300 yds.off Ellis Island on line with Liberty and Ellis Is.	Lat 40 41 44 Long 74 02 24	6	-	-	Clay	Unpolluted
111	"	300 feet off dock, Communipaw	Lat 40 42 17 Long 74 01 59	6	-	-	Sludge Clay	Polluted
112	"	100 yds.off 4th dock south of C.R.R. N.J. Ferry	Lat 40 42 14 Long 74 02 02	20	-	-	"	"
113	"	Halfway between C.R.R.of N.J. Ferry and Pier A	Lat 40 42 19 Long 74 01 34	50	-	-	"	Doubtful
114	Dec.22, 1908	500 feet southeast of Liberty Island	Lat 40 41 17 Long 74 02 33	40	-	Oily	Clay	Polluted
115	"	2500 feet southeast of Ellis Island	Lat 40 41 45 Long 74 01 52	40	-	"	Sludge Clay	"
116	"	2000 feet southeast of Ellis Island	Lat 40 41 38 Long 74 02 03	40	-	-	Clay	"
117	"	2800 feet southeast of Ellis Island	Lat 40 41 44 Long 74 01 47	40	-	Oily	Sludge Clay	"
118	"	1000 feet southeast of Liberty Island	Lat 40 41 08 Long 74 02 26	40	-	-	"	"
119	"	500 feet east of C.R.R.of N.J. Ferry	Lat 40 42 25 Long 74 01 57	40	Black	-	Sludge	"

Examination of Deposits from Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
120	Dec.22, 1908	500 feet southeast of C.R.R. of N.J. Ferry	Lat 40 42 22 Long 74 01 59	40	-	-	Sludge Clay	Polluted
121	"	2000 feet northeast of Liberty Island	Lat 40 41 37 Long 74 02 21	40	Black	-	"	"
122	Dec.24, 1908	200 feet north of Black Tom Pier	Lat 40 41 48 Long 74 03 10	8	Brown	-	Clay	Doubtful
123	"	100 yds.northeast of Black Tom	Lat 40 41 43 Long 74 03 08	8	"	-	Sludge Clay	"
124	"	Midway between Black Tom Water Tower and Liberty Island	Lat 40 41 22 Long 74 03 06	8	Black	-	Sludge	Unpollute
125	"	300 feet north of Liberty Island	Lat 40 41 30 Long 74 02 4	8	"	-	"	Doubtful
126	"	600 feet north of Liberty Island	Lat 40 41 34 Long 74 02 43	6	-	-	-	Polluted
127	"	West end Liberty Island to west end Ellis Island, midway	Lat 40 41 40 Long 74 02 41	6	Black	-	Sludge	"
128	"	200 yds.from S.W.Cor. of Ellis Island	Lat 40 41 53 Long 74 02 47	6	-	-	Sludge Clay	Doubtful
129	"	100 yds.off S.W. Cor. of Ellis Island	Lat 40 41 57 Long 74 02 42	6	-	-	"	"
130	"	200 feet off S.W.Cor.of Ellis Island on line Black Tom Water Tower	Lat 40 41 53 Long 74 02 40	6	-	-	"	Polluted
131	"	200 yds.from Ellis Island on line Black Tom Water Tower	Lat 40 41 52 Long 74 02 45	8	Black	-	Sludge	"
132	"	On line S.W.corner Ellis Island and Black Tom Water Tower, halfway	Lat 40 41 43 Long 74 02 54	8	-	-	Sludgy Clay	"
133	"	On line S.W.corner Ellis Island and Black Tom Water Tower, about halfway	Lat 40 41 38 Long 74 02 53	8	-	-	Sludge Clay	Doubtful

Examination of Deposits From the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth Water (feet)	Color	Odor	Consistency	Opinion
134	Dec.24, 1908	On line S.W.cor.of Ellis Island and Black Tom Water Tower, 200 yds.off Black Tom shore	Lat 40 41 39 Long 74 03 18	8	-	-	Sludge Clay	Unpolluted
135	"	On line S.W.cor.of Ellis Island and Black Tom Water Tower,100 yds.off Black Tom shore	Lat 40 41 38 Long 74 03 23	8	-	-	"	Polluted
136	"	On line S.E.cor.of Ellis Island and N.W.cor.Liberty,100 yds.off Ellis Island	Lat 40 41 44 Long 74 02 38	8	-	-	"	"
137	"	On line S.E.cor.of Ellis Island and N.W.cor.Liberty,midway	Lat 40 41 37 Long 74 02 39	8	-	-	"	"
138	"	100 yds.off N.W.cor.Ellis Island	Lat 40 42 04 Long 74 02 29	6	-	-	"	"
139	"	Near gas buoy 2,Black Tom channel	Lat 40 41 07 Long 74 02 37	15	-	Oily	Clay	"
140	"	Midway between buoys 2 and 4 Black Tom channel	Lat 40 41 12 Long 74 02 46	15	-	"	"	"
141	"	Between buoys 4 and 6 Black Tom channel	Lat 40 41 18 Long 74 02 52	15	-	-	Sludge Clay	"
142	"	Near Liberty Island	Lat 40 41 25 Long 74 02 48	8	-	-	"	"
143	"	Midway between Ellis Island and Liberty Island	Lat 40 41 42 Long 74 02 48	8	-	-	"	Doubtful
144	"	1000 feet north of Liberty Island	Lat 40 41 37 Long 74 02 45	6	-	-	"	Unpolluted
145	"	100 feet off S.W.corner of Ellis Island	Lat 40 41 57 Long 74 02 36	12	-	-	Clay	"
146	"	100 feet off center line of the west bulkhead,Ellis Island	Lat 40 42 00 Long 74 02 32	8	-	-	"	Doubtful
147	Feb.12, 1909	1000 feet west of Erie Basin	Lat 40 40 24 Long 74 01 20	35	Black	Oily tarry	Sludge Clay	Polluted
148		1500 feet west of Erie Basin	Lat 40 40 29 Long 74 01 25	15	"	"	Sludge Sand	"

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
149	Feb.12, 1909	2000 feet west of Erie Basin	Lat 40 40 34 Long 74 01 32	18	-	-	Sand	Unpolluted
150	"	2800 feet west of Erie Basin	Lat 40 40 37 Long 74 01 37	20	-	-	"	Polluted
151	"	3500 feet west of Erie Basin	Lat 40 40 40 Long 74 01 42	20	Black	Tarry Oily	Sludge Clay Sand	"
152	"	4000 feet west of Erie Basin	Lat 40 40 42 Long 74 01 49	20	"	"	Sludge Clay	"
153	"	4800 feet west of Erie Basin	Lat 40 40 47 Long 74 01 54	20	"	Oily	"	"
154	"	5000 feet west of Erie Basin	Lat 40 40 50 Long 74 02 00	20	"	-	Sand Sludge Clay	"
155	"	6000 feet west of Erie Basin	Lat 40 40 57 Long 74 02 10	30	"	-	Sludge Clay	"
156	"	5000 feet east of Black Tom	Lat 40 41 01 Long 74 02 19	30	"	-	"	"
157	"	4000 feet east of Black Tom	Lat 40 41 06 Long 74 02 30	10	"	-	"	"
158	"	800 feet south of Liberty Island	Lat 40 41 18 Long 74 02 38	10	"	-	Sludge Clay	"
159	"	800 feet south of Caven Point	Lat 40 41 38 Long 74 04 28	6	"	-	Sludge Clay	Unpolluted
160	"	1300 feet south of Caven Point	Lat 40 41 28 Long 74 04 26	6	"	-	"	"
161	"	1000 feet southeast of Caven Point	Lat 40 41 26 Long 74 04 21	10	"	-	"	"
162	"	1500 feet southeast of Caven Point	Lat 40 41 22 Long 74 04 22	10	"	-	"	Doubtful
163	"	1800 feet southeast of Caven Point	Lat 40 41 19 Long 74 04 11	10	"	-	"	"

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
164	Feb.12, 1909	2000 feet southeast of Caven Point	Lat 40 41 18 Long 74 03 56	10	Black	-	Sludge Clay	Unpolluted
165	"	3800 feet southeast of Caven Point	Lat 40 41 07 Long 74 03 41	10	"	-	"	"
166	"	4800 feet southeast of Caven Point	Lat 40 41 07 Long 74 03 27	10	-	-	Sand Clay	"

Ex. 28. P. 12

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of collection	Location of Samples — Approximate	Exact			Depth of water (feet)	Color	Odor	Consistency	Opinion
			°	'	"					
167	Feb.10, 1909	8000 feet east of buoy B 14 off Gowanus Bay	Lat	40	40 08	20	Black	Oily	Sludge	Polluted
			Long	74	01 43			tarry	Clay	
168	"	1000 feet east of buoy B 14 off Gowanus Bay	Lat	40	40 09	20	Black	Oily	Sludge	Polluted
			Long	74	01 53			tarry	Sand	
169	"	1000 feet north of Buoy B14 off Gowanus Bay	Lat	40	40 19	25		Oily	Sludge	Polluted
			Long	74	02 09				sand	
170	"	2000 feet northeast of buoy B 14 off Gowanus Bay	Lat	40	40 28	28	Black	Oily	Sludge	Polluted
			Long	74	02 18			tarry	clay	
171	"	3800 feet northeast of buoy B 14 off Gowanus Bay	Lat	40	40 38	30	Black		Sludge	Polluted
			Long	74	02 27				sand	
172	"	4020 feet northeast of buoy B 14 off Gowanus Bay	Lat	40	40 40	30	Brown	Oily	Sludge	Polluted
			Long	74	02 33				clay	
173	"	4800 feet northeast of buoy B '4 off Gowanus Bay	Lat	40	40 43	30	Black	Oily	Sludge	Polluted
			Long	74	02 37			tarry	sand	
174	"	800C feet northeast of buoy B 14 off Gowanus Bay	Lat	40	40 50	30	Black	Oily	Sludge	Polluted
			Long	74	02 38			tarry	sand	
175	"	8000 feet northeast of buoy B 14 off Gowanus Bay	Lat	40	40 47	30	Black		Sludge	Polluted
			Long	74	02 32				sand	
176	"	2800 feet north of buoy S 2	Lat	40	40 28	40	Black		Clay	Polluted
			Long	74	02 24				gravel	
177	"	2000 feet north of buoy S 2	Lat	40	40 28	38		Oily	Sludge	Polluted
			Long	74	02 30				sand	
178	"	1800 feet north of buoy S 2	Lat	40	40 29	38			Sludge	Polluted
			Long	74	03 00				clay	
179	"	2800 feet north of buoy S 2	Lat	40	40 31	40		Oily	Sand	Polluted
			Long	74	03 08				Sludge clay	
180	"	3800 feet north of buoy S 2	Lat	40	40 39	40	Black		Sludge	Polluted
			Long	74	03 10				clay	

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of Collection	Location of Samples — Approximate	Location of Samples — Exact ° ' "	Depth of water (feet)	Color	Odor	Consistency	Opinion
181	Feb.18, 1909	3000 feet north of buoy G 2	Lat 40 40 37 Long 74 03 14	40		Tarry Oily	Sludge clay	Polluted
182	"	3000 feet northeast of buoy G2	Lat 40 40 56 Long 74 03 19	30			Sludge clay	Polluted
183	"	1 mile northeast of buoy G 2	Lat 40 40 58 Long 74 03 33	30	Black		Sludge clay	Polluted
184	Feb.19,	Near buoy R 14 at mouth of Gowanus Bay	Lat 40 40 04 Long 74 02 06	30			Sludge sand	Polluted
185	"	800 feet northeast of buoy R 14	Lat 40 40 07 Long 74 02 02	30	Black	Oily	Sludge sand	Polluted
186	"	1000 feet east of buoy R 14	Lat 40 40 04 Long 74 01 57	30	Black	Oily	Sludge	Polluted
187	"	1600 feet east of buoy R 14	Lat 40 40 00 Long 74 01 50	30	Black	Oily	Sludge	Polluted
188	"	2800 feet east of buoy R 14	Lat 40 40 00 Long 74 01 40	30	Black	Oily tarry	Sludge	Polluted
189	"	2800 feet off southern end of Erie Basin	Lat 40 39 57 Long 74 01 34	30		Oily tarry	Sludge clay	Polluted
190	"	1900 feet off southern end of Erie Basin	Lat 40 39 54 Long 74 01 30	30		Oily tarry	Sludge clay	Polluted
191	"	1800 feet off southern end of Erie Basin	Lat 40 39 55 Long 74 01 28	30		Oily tarry	Sludge clay	Polluted
192	"	1800 feet off southern end of Erie Basin	Lat 40 39 53 Long 74 01 21	30		Oily tarry	Sludge clay	Polluted
193	"	900 feet off southern end of Erie Basin	Lat 40 39 52 Long 74 01 16	30	Black	Oily tarry	Sludge clay	Polluted
194	Feb.23,	8000 feet off 39th St. Brooklyn	Lat 40 39 40 Long 74 01 18	80	Black	Oily	Sludge	Polluted

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of collection	Location of Samples	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion
		Approximate						
195	Feb.23, 1909	2500 feet off 39th St. Brooklyn	Lat 40 39 38 Long 74 01 26	20	Black	Oily	Sludge	Polluted
196	"	2600 feet off 39th St. Brooklyn	Lat 40 39 42 Long 74 01 21	25	Black	Oily	Sludge sand clay	Polluted
197	"	1000 feet east of buoy N 14 off Gowanus Bay	Lat 40 40 00 Long 74 01 50	25	Black		Sludge clay	Polluted
198	"	1000 feet southeast of buoy N 14 off Gowanus Bay	Lat 40 39 57 Long 74 01 54	20	Black		Sludge clay	Polluted
199	"	Near buoy N 14 off Gowanus Bay	Lat 40 40 01 Long 74 02 12	25	Black		Sludge clay	Polluted
200	"	500 feet west of buoy N 14 off Gowanus Bay	Lat 40 40 08 Long 74 02 15	30	Black		Sludge clay	Polluted
201	"	1000 feet west of buoy N 14 off Gowanus Bay	Lat 40 40 08 Long 74 02 30	30			Sand	Polluted
202	"	1000 feet northwest of buoy N 14 off Gowanus Bay	Lat 40 40 14 Long 74 02 29	30	Black		Sludge clay	Polluted
203	"	2000 feet northwest of buoy N 14 off Gowanus Bay	Lat 40 40 21 Long 74 02 27	30	Black		Sludge clay	Polluted
204	"	3000 feet northwest of buoy N 14 off Gowanus Bay	Lat 40 40 19 Long 74 02 50	40	Black		Sludge clay	Polluted
205	Feb.26, 1909	1000 feet north of Buoy G 2	Lat 40 40 20 Long 74 03 08	40	Brown		Sand clay	Polluted
206	"	2500 feet northwest of buoy G 2	Lat 40 40 29 Long 74 03 13	10				Polluted
207	"	3000 feet northwest of buoy G 2	Lat 40 40 38 Long 74 03 16	10			clay	Polluted
208	"	4000 feet northwest of buoy G 2	Lat 40 40 37 Long 74 03 23	10	Black		clay	Doubtful

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion
209	Feb.26, 1909	5000 feet northwest of buoy G 2	Lat 40 40 44 Long 74 03 28	10	Black		Clay	Unpolluted
210	"	1 mile northwest of buoy G 2	Lat 40 40 52 Long 74 03 28	10	Black		Clay	Polluted
211	"	3500 feet northeast of P.R.R. terminal, Greenville	Lat 40 40 57 Long 74 03 39	8	Black		Clay	Doubtful
212	"	3000 feet northeast of P.R.R. terminal, Greenville	Lat 40 40 57 Long 74 03 44	8	Black		Clay	Doubtful
213	"	3500 feet north of P. R. R. terminal, Greenville	Lat 40 41 03 Long 74 03 52	8	Black		Clay	Unpolluted
214	"	3000 feet southeast of Caven Point	Lat 40 41 04 Long 74 04 00	8	Brown		Sub-soil	Doubtful
215	"	2000 feet southeast of Caven Point	Lat 40 41 11 Long 74 04 04	8	Brown		Sub-soil	Unpolluted
216	"	2000 feet south of Caven Point	Lat 40 41 12 Long 74 04 15	4	Brown		Sub-soil	Unpolluted
217	"	3000 feet south of Caven Point	Lat 40 41 03 Long 74 04 18	4			Clay	Unpolluted
218	"	3500 feet south of Caven Point	Lat 40 40 57 Long 74 04 13	4			Clay	Doubtful
219	"	2500 feet northeast of P.R.R. terminal, Greenville	Lat 40 40 54 Long 74 04 01	8			Clay	Unpolluted
220	"	2000 feet northeast of P.R.R. terminal, Greenville	Lat 40 40 50 Long 74 03 57	8			Clay	Unpolluted
221	"	3000 feet northeast of P.R.R. terminal, Greenville	Lat 40 40 47 Long 74 03 50	8			Clay	Unpolluted
222	"	3000 feet east of P. R. R. terminal, Greenville	Lat 40 40 42 Long 74 03 42	12	Black		Sub-soil	Doubtful

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of Collection	Location of Samples: Approximate	Exact ° ' "	Depth of water (feet)	Color	Odor	Consistency	Opinion
223	Feb.26, 1909	2500 feet east of P. R. R. terminal, Greenville	Lat 40 40 39 Long 74 03 36	12	Black		Clay	Doubtful
224	"	3800 feet east of P. R.R. terminal, Greenville	Lat 40 40 31 Long 74 03 28	12	Black		Clay	Polluted
225	"	4000 feet east of P. R.R. terminal, Greenville	Lat 40 40 23 Long 74 03 23	15	Black		Clay	Polluted
226	"	1500 feet northwest of buoy G 2	Lat 40 40 19 Long 74 03 14	12	Black	Oily	Sludge subsoil	Polluted
227	"	1000 feet northwest of buoy G 2	Lat 40 40 10 Long 74 03 06	12		Oily	Sludge sand gravel	Polluted
228	"	500 feet northeast of Buoy G 2	Lat 40 40 05 Long 74 02 55	20		Oily	Sludge sand gravel	Doubtful
229	"	1000 feet south of buoy G 2	Lat 40 39 52 Long 74 02 52	40	Black	Oily	Sludge clay	Doubtful
230	"	1500 feet southeast of buoy G 2	Lat 40 39 50 Long 74 02 43	50			Sludge sand	Doubtful
231	Feb.27, 1909	3/4 mile southwest of buoy N 14 off Gowanus Bay	Lat 40 39 36 Long 74 02 52	30		Oily	Sludge sand, clay	Unpolluted
232	"	1/2 mile southwest of buoy N 14 Off	Lat 40 39 49 Long 74 02 38	30		Oily	Sludge sand	Polluted
233	"	1/2 mile southwest of buoy N 14	Lat 40 39 45 Long 74 02 32	30		Oily	Sludgy sand	Polluted
234	"	2400 feet south of buoy N 14	Lat 40 39 40 Long 74 02 24	30			Sand	Polluted
235	"	2300 feet south of buoy N 14	Lat 40 39 38 Long 74 02 08	30	Black	Oily	Clay sand	Polluted
236	"	3000 feet southeast of buoy	Lat 40 39 54 Long 74 01 58	20	Black	Oily	Clay	Polluted

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of Collection	Location of Samples — Approximate	Exact			Depth of water (feet)	Color	Odor	Consistency	Opinion
237	Feb.27, 1909	3500 feet southeast of buoy N 14	Lat	40	39 33	20	Black	Oily	Clay	Polluted
			Long	74	01 51					
238	"	2600 feet off shore opposite 40th St. Brooklyn	Lat	40	39 27	20		Oily	Sand	Polluted
			Long	74	01 40					
239	"	2100 feet off shore opposite 39th St. Brooklyn	Lat	40	39 27	20	Black		Sludge clay	Polluted
			Long	74	01 28					
240	"	About 1 mile northeast of Robbins Reef light	Lat	40	39 40	40	Black	Oily	Clay	Polluted
			Long	74	02 51					
241	"	About 1 mile northeast of Robbins Reef light	Lat	40	39 43	40	Black	Oily	Clay	Polluted
			Long	74	03 01					
242	"	About 7/8 mile northeast of Robbins Reef light	Lat	40	39 49	40	Black	Oily	Clay	Polluted
			Long	74	03 08					
243	"	About 1 mile northeast of Robbins Reef light	Lat	40	39 55	40	Black	Oily	Clay	Polluted
			Long	74	03 07					
244	"	About 1 mile north of Robbins Reef light	Lat	40	40 03	40	Black		Sludge subsoil	Polluted
			Long	74	03 13					
245	"	About 1 mile north of Robbins Reef light	Lat	40	40 09	40	Black		Sludge	Polluted
			Long	74	03 22					
246	"	About 1 mile north of Robbins Reef light	Lat	40	40 08	40	Black		Sludge	Polluted
			Long	74	03 34					
247	"	About 1 mile north of Robbins Reef light	Lat	40	40 16	40	Brown		Subsoil	Doubtful
			Long	74	03 42					
248	"	About 1 mile north of Robbins Reef light	Lat	40	40 20	40	Brown		Subsoil	Polluted
			Long	74	03 54					
249	Mar.3, 1909	1600 feet off shore 65th St. Brooklyn	Lat	40	38 49	30	Brown		Subsoil	Polluted
			Long	74	02 16					
250	"	1700 feet off shore 65th St. Brooklyn	Lat	40	38 53	30	Brown		Subsoil	Polluted
			Long	74	02 08					

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued.)

Examination No.	Date of Collection	Location of Samples	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion
		Approximate	° ' "					
251	Mar.3, 1909	2800 feet off shore 65th St. Brooklyn	Lat 40 38 57 Long 74 02 20	30			Sand	Polluted
252	"	3600 feet off shore 65th St. Brooklyn	Lat 40 39 02 Long 74 02 25	30		Oily	Sand	Polluted
253	"	3300 feet off shore 65th St. Brooklyn	Lat 40 38 55 Long 74 02 36	30		Oily	Sand	Polluted
254	"	4200 feet off shore 65th St. Brooklyn	Lat 40 39 02 Long 74 02 43	30		Oily	Sand	Doubtful
255	"	1 mile off shore 65th St. Brooklyn	Lat 40 39 04 Long 74 02 51	30		Oily	Sludge sand	Polluted
256	"	1 mile off shore 65th St. Brooklyn	Lat 40 38 58 Long 74 02 55	30	Brown	Oily	Clay sand	Polluted
257	"	1/2 mile east of Robbins Reef bell buoy	Lat 40 39 11 Long 74 03 09	35	Brown		Clay	Doubtful
258	Mar.6, 1909	1800 feet off shore 60th St. Brooklyn	Lat 40 39 00 Long 74 01 52	30	Brown	Oily	Clay	Polluted
259	"	2600 feet off shore 62nd St. Brooklyn	Lat 40 38 58 Long 74 02 08	30	Black		Sludge clay	Polluted
260	"	3200 feet off shore 60th St. Brooklyn	Lat 40 39 03 Long 74 02 08	30			Sand	Doubtful
261	"	3900 feet off shore 60th St. Brooklyn	Lat 40 39 09 Long 74 02 14	30			Sand	Unpolluted
262	"	4400 feet off shore 60th St. Brooklyn	Lat 40 39 12 Long 74 02 21	30		Oily	Sludge sand	Polluted
263	"	1 mile off shore 60th St. Brooklyn	Lat 40 39 17 Long 74 02 27	30		Oily	Sludge sand	Polluted
264	"	1 1/4 mile off shore 60th Brooklyn	Lat 40 39 22 Long 74 02 40	30		Oily	Sludge sand	Polluted
265	"	1 1/8 mile off shore 60th Brooklyn	Lat 40 39 13 Long 74 02 42	35		Oily	Sludge sand	Polluted

Examination of Deposits from the Harbor Bottom. Upper Bay. (Continued.)

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Lat / Long	°	'	"	Depth of water (feet)	Color	Odor	Consistency	Opinion
266	Mar.6, 1909	1 1/2 mile off shore 60th St. Brooklyn		Lat	40	39	28	38	Brown		Clay	Polluted
				Long	74	02	54					
267	"	1 3/4 mile off shore 60th St. Brooklyn		Lat	40	39	38	38	Black	Oily	Clay	Unpolluted
				Long	74	03	06					
268	"	900 feet north of Robbins Reef Bell buoy		Lat	40	39	24	40			Gravel	Unpolluted
				Long	74	03	52					
269	"	1000 feet northeast of Robbins Reef bell buoy		Lat	40	39	17	40			Sludge clay	Polluted
				Long	74	03	40					
270	"	2000 feet east of Robbins Reef Bell buoy		Lat	40	39	07	40	Black	Oily	Sludge clay	Polluted
				Long	74	03	87					
271	"	2800 feet east of Robbins Reef bell buoy		Lat	40	39	08	40	Black	Oily	Clay	Polluted
				Long	74	03	19					
272	"	1 mile off shore, 65th St. Brooklyn		Lat	40	39	11	30		Oily	Sludge sand	Polluted
				Long	74	02	80					
273	"	1200 feet south of Robbins Reef light		Lat	40	39	04	40	Black	H S	Subsoil	Doubtful
				Long	74	03	88			S		
274	"	3/4 mile south of Robbins Reef light		Lat	40	38	80	38		Oily	Sand gravel	Doubtful
				Long	74	04	08					
275	"	3000 feet southwest of Robbins Reef light		Lat	40	39	04	38			Gravel	Doubtful
				Long	74	04	82					
276	"	3000 feet south of Robbins Reef light		Lat	40	38	57	30			Sand	Doubtful
				Long	74	04	08					
277	"	7/8 mile south of Robbins Reef light		Lat	40	38	39	38			Sand	Doubtful
				Long	74	03	53					

Examination of Deposits from the Harbor Bottom, Cheesequake Creek.

Examination No.	Date of Collection	Location of Samples — Approximate		Depth of water (feet)	Color	Odor	Consistency	Opinion	Bottom per Sq. m.
278	Mar.30, 1909	Cheesequake Creek, Lawrence Harbor, N.J.	Exact Lat 40 27 30 Long 74 16 00	2	Gray	Marshy	Clay	Unpolluted	15,000
279	"	Cheesequake Creek, Lawrence Harbor, N.J.	Lat 40 27 30 Long 74 16 00	2	Gray	Marshy	Clay	Unpolluted	9,000

Ex. 98. P. 81

STATE OF NEW YORK vs. STATE OF NEW JERSEY. 2842

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion
280	Mar.23, 1909	3300 feet off Owl Head	Lat 40 38 27 Long 74 38 56	40	Black		Clay	Polluted
281	"	500 feet north of 71st St. sewer, 600 ft. off shore	Lat 40 38 23 Long 74 02 17	40	Brown	H_2S	Subsoil	Polluted
282	"	1500 feet from Brooklyn shore midway between Bliss tower and 71st St. sewer	Lat 40 38 21 Long 74 02 34	40	Black		Clay	Polluted
283	Mar.24,	2800 feet northwest of Owl Head bell buoy	Lat 40 38 45 Long 74 03 41	25	Black	Oily	Subsoil	Doubtful
284	"	2600 feet southwest of Owl Head bell buoy	Lat 40 38 40 Long 74 03 41	25	Black	Oily	Subsoil	Polluted
285	"	2100 feet northwest of Owl Head bell buoy	Lat 40 38 39 Long 74 03 34	25	Black	Oily	Subsoil	Polluted
286	"	2200 feet northwest of Owl Head bell buoy	Lat 40 38 40 Long 74 03 28	25	Black	Oily	Subsoil	Polluted
287	"	1200 feet north of Owl Head bell buoy	Lat 40 38 35 Long 74 03 22	30			Sludge sand	
289	"	900 feet north of Owl Head bell buoy	Lat 40 38 22 Long 74 03 17	30			Sand gravel	Polluted
290	"	1300 feet northwest of Owl bell buoy	Lat 40 38 36 Long 74 03 41	30			Sand gravel	Polluted
291	"	1600 feet east of Owl Head bell buoy	Lat 40 38 24 Long 74 02 58	30	Black		Subsoil clay	Polluted
292	"	2200 feet east of Owl Head bell buoy	Lat 40 38 21 Long 74 02 50	40	Black		Silt sand	Polluted
293	"	2100 feet east of Owl Head bell buoy	Lat 40 38 24 Long 74 02 51	40	Black		Silt sand	Polluted

Examination of Deposits from the Harbor Bottom Upper Bay.

Examination No.	Date of Collection	Location of Samples	Exact o ' "	Depth of water (feet)	Color	Odor	Consistency	Opinion
294	Mar.24, 1909	2700 feet east of Owl Head bell buoy	Lat 40 38 24 Long 74 02 43	40	Black		Silt sand	Polluted
295	"	2800 feet east of Owl Head bell buoy	Lat 40 38 20 Long 74 02 41	40			Silt sand	Polluted
296	"	3200 feet east of Owl Head bell buoy	Lat 40 38 24 Long 74 02 37	40	Black	Oily	Silt sand	Polluted
297	"	4200 feet east of Owl Head bell buoy	Lat 40 38 25 Long 74 02 26	40	Black		Sand clay	Polluted
298	"	600 feet off Owl Head	Lat 40 38 27 Long 74 02 19	40	Black		Sand clay	Polluted
299	"	700 feet off Owl Head	Lat 40 38 18 Long 74 02 30	40	Black		Subsoil	Polluted

Ex. 98. P. 23

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection.	Location of Samples — Approximate	Exact	Depth of water	Color	Odor	Consistency	Opinion	Bacteria per gram
300	Mar.27,1909	4000 ft. west of Robbins Reef, light	Lat 40 39 33 Long 74 04 43	8	Black	-	Sub-soil	Unpolluted	900,000
301	" " "	5000 ft. west of Robbins Reef, light	Lat 40 39 30 Long 74 05 02	8	"	-	" "	" "	950,000
302	" " "	4500 ft. west of Robbins Reef, light	Lat 40 39 28 Long 74 04 57	8	"	Oily	" "	" "	1,100,000
303	" " "	4000 ft. west of Robbins Reef, light	Lat 40 39 22 Long 74 04 51	8	"	"	" "	Doubtful	740,000
304	" " "	3600 ft. west of Robbins Reef, light	Lat 40 39 21 Long 74 04 46	8	"	"	" "	Polluted	850,000
305	" " "	3000 ft. southwest of Robbins Reef, light	Lat 40 39 18 Long 74 04 37	20	"	"	" "	" "	640,000
306	" " "	2700 ft. southwest of Robbins Reef, light	Lat 40 39 17 Long 74 04 31	20	"	"	" "	Unpolluted	690,000
307	" " "	2200 ft. southwest of Robbins Reef, light	Lat 40 39 17 Long 74 04 24	20	"	"	" "	Polluted	1,000,000
308	" " "	1800 ft. southwest of Robbins Reef, light	Lat 40 39 18 Long 74 04 17	20	"	"	" "	Unpolluted	770,000
309	" 29, "	1200 ft. southwest of Robbins Reef, light	Lat 40 39 23 Long 74 04 15	40	-	-	Sand Silt	" "	160,000
310	" " "	1000 ft. southwest of Robbins Reef, light	Lat 40 39 18 Long 74 04 08	40	-	-	Silt Sand	Doubtful	670,000
311	" " "	1600 ft. south of Robbins Reef, light	Lat 40 39 11 Long 74 04 05	70	-	-	Gravel	Unpolluted	-
312	" " "	2800 ft. south of Robbins Reef, light	Lat 40 38 53 Long 74 03 56	30	-	Oily	Silt Sand	Polluted	490,000
313	" " "	3200 ft. south of Robbins Reef, light	Lat 40 38 55 Long 74 03 51	40	-	"	Clay	" "	720,000
314	" " "	1800 ft. south of Robbins Reef, light	Lat 40 38 59 Long 74 03 48	70	Black	"	Sub-soil	" "	840,000
315	" " "	2200 ft. southeast of Robbins Reef bell buoy	Lat 40 38 55 Long 74 03 39	50	"	-	Clay	" "	630,000

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection.	Location of Samples		Depth of water	Color	Odor	Consistency	Opinion	Bacteria per gram.
		Approximate	Exact ° ' "						
316	Mch. 29,1909	2800 ft. southeast of Robbins Reef bell buoy	Lat 40 38 52 Long 74 03 20	50	Black	-	Clay	Polluted	660,000
317	" " "	2500 ft. north of Owl Head bell buoy	Lat 40 38 52 Long 74 03 10	38	"	Oily	"	"	1,200,000
318	" " "	2600 ft. " " " "	Lat 40 38 52 Long 74 03 06	38	"	"	"	"	1,600,000
319	" " "	2900 ft. " " " "	Lat 40 38 52 Long 74 03 10	38	"	-	"	"	940,000
320	" " "	2600 ft. " " " "	Lat 40 38 47 Long 74 03 02	38	-	-	Sand	"	180,000
321	" " "	2800 ft. northeast of Owl Head bell buoy	Lat 40 38 44 Long 74 02 53	30	-	Oily	Silty Sand	"	320,000
322	" " "	3000 ft. off shore at Owls Head, Brooklyn	Lat 40 38 40 Long 74 02 43	40	-	-	Silty Sand	"	240,000
323	" " "	2400 ft. " " " "	Lat 40 38 39 Long 74 02 36	40	-	-	Silty Sand	"	440,000
324	" " "	1800 ft. " " " "	Lat 40 38 35 Long 34 02 27	40	Black	-	Clay	"	840,000
325	" 30, "	Line from 71 St. Sewer to St. George 300 ft. off shore	Lat 40 38 14 Long 74 02 17	40	-	Oily	Sand Clay	"	6,400,000
326	" " "	100 ft." " " " "	Lat 40 38 14 Long 74 02 26	40	-	"	Sand	"	1,800,000
327	" " "	Opposite 71st St. Bklyn.	Lat - - - - Long - - - -	40	Brown	-	Sub-soil	"	5,300,000
328	" " "	About 600 ft. off Bay Ridge	Lat 40 38 09 Long 74 02 30	40	Brown	-	Sub-soil	"	1,100,000
329	" " "	" 900 ft. " "	Lat 40 38 22 Long 74 02 28	40	"	-	Sub-soil	"	900,000
330	" " "	1800 ft. " "	Lat 40 38 17 Long 74 02 36	40	"	Oily	Sub-soil	"	280,000
331	" " "	2400 ft. " "	Lat 40 38 18 Long 74 02 43	40	"	-	Sub-soil	"	1,000,000

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Sample: Approximate	Exact Lat ° ' "	Exact Long ° ' "	Depth of water	Color	Odor	Consistency	Opinion	Bacteria per gram
332	Mch. 30,1909	2600 ft. off Bay Ridge	Lat 40 38 17	Long 74 02 80	40	-	-	Silt sand	Polluted	600,000
333	" " "	3000 ft. " " "	Lat 40 38 21	Long 74 02 54	40	Black	Oily	Sand clay	"	2,400,000
334	" " "	3800 ft. " " "	Lat 40 38 20	Long 74 03 02	40	-	-	silt sand	"	4,200,000
335	" " "	At Owl Head bell buoy	Lat 40 38 21	Long 74 03 14	25	-	-	silt sand	"	3,200,000
336	" " "	900 ft. west of Owl Head bell buoy	Lat 40 38 24	Long 74 03 26	35	Black	-	clay	Doubtful	2,100,000
337	" " "	1600 ft. northwest of Owl Head bell buoy	Lat 40 38 28	Long 74 03 32	35	Black	Oily	"	Polluted	480,000
338	" " "	2600 ft. " "	Lat 40 38 32	Long 74 03 44	40	"	"	"	"	330,000
339	" " "	3000 ft. " "	Lat 40 38 34	Long 74 03 50	40	-	"	sand	"	460,000

Ex. 98. P. 26

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of water	Color	Odor	Consistency	Opinion	Bacteria per gram
340	Apr. 12,1909	Breakwater at Pier A N.R.	Lat 40 41 18 Long 74 01 09	30	-	-	Sediment	Polluted	-
341	" " "	About 1800 ft. off the S.W. corner of pier A	Lat 40 40 18 Long 74 01 20	90	Black	Oily	Silt gravel	Doubtful	-

Ex. No. 2. 27

Examination of Deposits from the Harbor Bottom, Hempstead Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact Lat	Exact Long	Depth in feet Water	Depth in feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
342	Apr. 6,1909	200 ft. back of house of John L.Lawrence	Lat 40 37 00 Long 73 42 00		4	0.0	Brown	Marshy	Clay	Unpolluted	48,000
343	" " "	Same as No. 342	Lat 40 39 00 Long 73 42 00		4	0.8	Black	Marshy	"	-	80,000
344	" " "	300 feet farther out	Lat 40 37 00 Long 73 42 00		4	0.0	Brown	Marshy	"	"	98,000
345	" " "	Same as No.344	Lat 40 39 00 Long 73 42 00		4	0.8	Black	Marshy	"	"	88,000
346	" " "	In middle of creek	Lat 40 37 00 Long 73 42 00		4	0.0	Brown	Marshy	"	Polluted	48,000
347	" " "	" " " "	Lat 40 39 00 Long 73 42 00		4	0.8	Black	Marshy	"	Unpolluted	18,000
348	" " "	Back of house of John L. Lawrence	Lat 40 37 00 Long 73 42 00		4	0.0	Brown	Marshy	"	"	88,000
349	" " "	" " " "	Lat 40 37 00 Long 73 42 00		4	0.7	Gray	Loamy	"	Doubtful	19,000

Ex. 98. P. 29

Examination of Deposits from the Harbor Bottom. Pelham Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact ° ' "	Depth in feet Water	Depth in feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
350	Apr. 5,1909	Shore of Pelham Bay Park 600 ft. W.of Bathing Beach	Lat 40 52 12 Long 73 48 18	3	0	Brown	-	Sand	Unpolluted	1,000
351	" " "	Same as 350	Lat 40 52 12 Long 73 48 18	3	0.5	-	-	"	"	1,000
352	" " "	Shore of Pelham Bay Park 300 ft. E.of Bathing Beach	Lat 40 52 02 Long 73 48 18	3	0	Brown	-	Clay	"	53,000
353	" " "	Same as 352	Lat 40 52 02 Long 73 48 18	3	0.5	Brown	-	"	"	6,000
354	" " "	Extreme west end of same inlet near Bartow's Station	Lat 40 52 13 Long 73 48 34	3	0.0	--	-	"	"	80,000
355	" " "	Same as 354	Lat 40 52 13 Long 73 48 24	3	0.5	-	-	"	"	9,000

Examination of Deposits from the Harbor Bottom. Long Island Sound.

Examination No.	Date of collection	Location of Samples Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion	Bacteria per gram
356	Apr. 13,1909	Greenpoint Harbor at oyster beds	Lat 41 06 00 Long 72 21 05	18	Yellow	-	Sand	Unpolluted	4,0000

Ex. 98. P. 30

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of water Feet	Color	Odor	Consistency	Opinion
357	Apr.17,1909	From 79 St. Sewer to Tompkinsville, 650 ft. out from sewer	Lat 40 37 35 Long 74 02 28	30	Black	Oily	sub-soil	Polluted
358	" " "	300 ft. off 79 St. Brooklyn	Lat 40 37 51 Long 74 02 33	30	"	-	sludge sand	"
359	" " "	800 ft. " "	Lat 40 37 54 Long 74 02 38	30	-	-	silty sand	"
360	" " "	1400 ft. " "	Lat 40 37 55 Long 74 02 45	40	-	-	" "	"
361	" " "	2400 ft. " "	Lat 40 37 58 Long 74 02 56	40	-	-	" "	"
362	" " "	3000 ft. " "	Lat 40 38 01 Long 74 03 03	40	-	-	" "	"
363	" " "	2800 ft. " "	Lat 40 38 03 Long 74 02 59	40	-	Oily	sludge clay sand	"
364	" " "	3500 ft. " "	Lat 40 38 02 Long 74 03 11	40	-	-	silt sand	"
365	" " "	4000 ft. " "	Lat 40 38 05 Long 74 03 17	50	-	Oily	sand	Doubtful
366	" " "	500 ft. west of Owl Head bell buoy	Lat 40 38 18 Long 74 03 22	35	-	"	silty sand	Polluted
367	" " "	4000 ft. off Tompkinsville, S.I.	Lat 40 38 12 Long 74 03 37	45	Brown	"	sub-soil	"
368	" " "	2400 ft. " "	Lat 40 38 20 Long 74 03 55	55	-	-	sand gravel	Unpolluted
369	" " "	100 ft. off Pier 1 Staten Island	Lat 40 38 23 Long 74 04 12	35	-	Oily	" "	Polluted

Examination of Deposits from the Harbor Bottom. Long Island Sound.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion	Bacteria per gram
370	Apr.13,1909	Gardener's Bay near Orient Point	Lat 41 09 00 Long 72 12 30	30	Brown	-	Clay	Unpolluted	3,000
371	" " "	½ mile off Roanoke Pt.	Lat 41 00 30 Long 72 42 00	35	"	-	"	"	6,000
372	" " "	½ mile off Woodville Landing	Lat 40 59 50 Long 72 49 45	35	Gray	-	"	"	5,000
373	" " "	Port Jefferson Harbor just inside breakwater	Lat 40 57 00 Long 73 05 00	20	"	-	"	"	32,000
374	" 15 "	½ mile off Eaton's Point	Lat 40 59 30 Long 73 22 30	55	"	-	"	"	16,000
375	" " "	1 mile off Lloyd's Point	Lat 40 57 45 Long 73 29 10	45	"	-	"	"	12,000
376	" " "	1 mile off Center Is. Point	Lat 40 56 30 Long 73 23 00	35	"	-	sand clay	"	17,000
377	" " "	1 mile off Matinicock Point	Lat 40 55 20 Long 73 38 25	55	"	-	"	"	22,000
378	" " "	1 mile off Prospect Point	Lat 40 52 45 Long 73 44 25	50	"	-	"	"	18,000
379	" " "	Eastchester Bay, near City Is.	Lat 40 50 00 Long 73 47 30	15	"	-	"	"	60,000
380	" " "	300 ft. east of Throgs Neck	Lat 40 48 20 Long 73 47 20	28	"	-	"	"	140,000

Ex. 78. P. 32

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion
381	Apr. 21,1909	600 ft. from Crescent Club Brooklyn.	Lat 40 37 39 Long 74 02 40	40	Black	-	sludge sub-soil	Polluted
382	" " "	1200 ft. " "	Lat 40 37 42 Long 74 02 47	70	-	Oily	sand	"
383	" " "	2100 ft. " "	Lat 40 37 38 Long 74 02 56	70	-	-	"	Doubtful
384	" " "	3800 ft. " "	Lat 40 37 37 Long 74 03 12	70	-	-	sand silt	"
385	" " "	Midstream, opposite Crescent Club, Brooklyn	Lat 40 37 37 Long 74 03 22	80	-	-	sand	Unpolluted
386	" " "	3800 ft. out from Tompkinsville, S.I.	Lat 40 37 42 Long 74 03 38	60	Black	-	sub-soil	Polluted
387	" " "	2400 ft. " "	Lat 40 37 40 Long 74 03 50	60	"	-	sludge clay	"
388	" " "	1100 ft. " "	Lat 40 37 43 Long 74 03 59	60	"	-	" "	"
389	" " "	1200 ft. out from Stapleton, S. I.	Lat 40 37 50 Long 74 04 11	60	Grey	Oily	clay	Unpolluted
390	" " "	800 ft. out from "	Lat 40 37 51 Long 74 04 21	40	Black	-	sludge clay	Polluted
391	" " "	400 ft. off shore nearly opposite 89 St.Brooklyn	Lat 40 37 25 Long 74 02 38	30	-	Oily	sludge sand	"
392	" " "	1600 ft. " "	Lat 40 37 28 Long 74 02 48	70	-	-	sand	"
393	" " "	2500 ft. out from Crescent Club, Brooklyn.	Lat 40 37 29 Long 74 02 58	70	-	-	"	Unpolluted
394	" " "	Midstream opposite Crescent Club, Brooklyn	Lat 40 37 35 Long 74 03 07	80	-	-	silt sand	"
395	" " "	" "	Lat 40 37 37 Long 74 03 22	80			" "	Polluted

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact Lat. ° ' "	Exact Long. ° ' "	Depth of water Feet	Color	Odor	Consistency	Opinion
396	Apr. 24,1909	About 2000 ft. off 39 St. Brooklyn,	Lat 40 37 23	Long 74 02 54	70		Oily	sludge sand	Polluted
397	" " " "	1800 ft. "	Lat 40 37 27	Long 74 02 52	70	"	"	sand	"
398	" " " "	1900 ft. "	Lat 40 37 28	Long 74 02 56	70	"	"	"	Unpolluted
399	" " " "	2300 ft. "	Lat 40 37 32	Long 74 02 59	70	"	"	"	Doubtful
400	" " " "	2200 ft. "	Lat 40 37 29	Long 74 02 58	70	"	"	"	"
401	" " " "	2600 ft. "	Lat 40 37 30	Long 74 03 00	70	"	"	silty sand	Unpolluted
402	" " " "	3000 ft. "	Lat 40 37 33	Long 74 03 04	70	"	"	" "	Polluted
403	" " " "	3000 ft. "	Lat 40 37 28	Long 74 03 09	70	"	"	" "	"
404	" " "	Midstream, opposite 39 St Brooklyn	Lat 40 37 28	Long 74 03 16	80	"	"	sand gravel	Doubtful
405	" " "	About midstream, opposite 39 St. Brooklyn	Lat 40 37 28	Long 74 03 22	80	"	"	" "	"
406	" " "	About 4800 ft. opposite pier Canal St. Stapleton, S.I.	Lat 40 37 30	Long 74 03 35	80	"	"	sand clay	"
407	" " " "	4000 ft. "	Lat 40 37 34	Long 74 03 43	80	"	"	clay sand	Polluted
408	" " " "	3000 ft. "	Lat 40 37 34	Long 74 03 32	80	Black	Oily	clay	Doubtful
409	" " "	400 ft. off Canal St. pier, Stapleton, S.I.	Lat 40 37 36	Long 74 04 20	38	"	"	clay	Polluted
410	" " "	400 ft. off 91 St. Brooklyn	Lat 40 37 09	Long 74 02 40	90	"	"	sand	"

Ex. 96. P. 34

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact ° ' "	Depth of water feet	Color	Odor	Consistency	Opinion
411	Apr.24,1909	1000 ft. off 91 St. Brooklyn	Lat 40 37 10 Long 74 02 48	70	-	Oily	Sand	Polluted
412	" " "	1500 ft. " "	Lat 40 37 39 Long 74 02 48	70	Black	"	Sludge Clay	"
413	" " "	1700 ft. " "	Lat 40 37 10 Long 74 02 52	70	-	-	Silty Sand	"
414	" " "	1900 ft. " "	Lat 40 37 10 Long 74 02 50	70	-	-	" "	"
415	" " "	Midstream opposite 91 St.Brooklyn	Lat 40 37 07 Long 74 03 10	80	-	-	Sand	Unpolluted
416	" 29 "	About ¼ mile off 89 St. Brooklyn	Lat 40 37 12 Long 74 03 03	40	-	Oily	Silty Sand	Polluted
417	" " "	Opposite 89 St. Brooklyn, midstream	Lat 40 37 12 Long 74 03 19	70	-		" "	Unpolluted
418	" " "	About 1500 ft. off Staten Is. shore opposite Clifton	Lat 40 37 12 Long 74 03 28	70	-	-	Sand	Polluted
419	" " "	" 800 ft. "	Lat 40 37 12 Long 74 03 36	90	-	-	-	"
420	" " "	About 1800 ft. out from dock at Clifton S.I.	Lat 40 37 12 Long 74 03 45	70	Black	-	Clay	Doubtful

Ex. 98. P. 38

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples		Depth of water Feet	Color	Odor	Consistency	Opinion
		Approximate	Exact ° ' "					
421	May 3,1909	50 ft. off New Jersey shore opposite Riverdale	Lat 40 54 25 Long 73 55 56	15	Brown Black	-	Clay	Unpolluted
422	" " "	900 ft. " " "	Lat 40 54 22 Long 73 55 44	20	Brown Black	-	"	"
423	" " "	¼ mile off New Jersey shore opposite Riverdale	Lat 40 54 21 Long 73 55 37	30	" "	-	"	"
424	" " "	3/8 " " " "	Lat 40 54 20 Long 73 55 31	35	Black	-	Sub-Soil	"
425	" " "	Midstream opposite Riverdale	Lat 40 54 18 Long 73 55 24	35	Gray	-	" "	"
426	" " "	2300 ft. off shore Riverdale	Lat 40 54 17 Long 73 55 20	40	Black	-	" "	"
427	" " "	1800 ft. off shore Riverdale	Lat 40 54 17 Long 73 55 15	40	-	-	Sand Gravel	"
428	" " "	1200 ft. off shore Riverdale	Lat 40 54 15 Long 73 55 09	45	Black	-	Clay	Doubtful
429	" " "	About 200 ft. out from Riverdale dock	Lat 40 54 12 Long 73 54 57	20	Black	-	"	"

Ex. 98. P. 36

Examination of Deposits from the Harbor Bottom, The Narrows.

Examination No.	Date of collection	Location of Samples — Approximate	Exact ° ' "	Depth of water Feet	Color	Odor	Consistency	Opinion
430	May 5,1909	About 500 ft. out from dock above Ft. Lafayette	Lat 40 36 52 Long 74 02 35	40	Black	-	Sludge Clay	Polluted
431	" " "	" 800 ft. "	Lat 40 36 52 Long 74 02 40	40	-	-	Silty sand	"
432	" " "	" 1800 ft. "	Lat 40 36 48 Long 74 02 47	60	Black	-	Sludge Clay Sand	"
433	" " "	" 1400 ft. "	Lat 40 36 49 Long 74 02 46	70	-	-	Gravel Sand	"
434	" " "	" 400 ft. "	Lat 40 36 52 Long 74 02 39	40	Gray	-	Clay	"
435	" 6, "	Midstream opposite Quarantine Station	Lat 40 36 52 Long 74 03 00	80	-	-	Sandy Clay	"
436	" " "	About ¼ mile opposite Quarantine Station	Lat 40 36 50 Long 74 02 54	80	-	-	" "	"
437	" " "	About 300 ft. off Staten Island shore 500 ft.N.of Quarantine	Lat 40 36 45 Long 74 03 39	50	Black	Oily	Sludge Sub-soil	Doubtful
438	" " "	" 1000 ft. " "	Lat 40 36 47 Long 74 03 29	50	"	-	" "	"
439	" " "	" 1600 ft. " "	Lat 40 36 47 Long 74 03 20	50	-	Oily	Silt Sand	"
440	" " "	About ½ mile off Quarantine Station	Lat 40 36 42 Long 74 03 09	50	-	-	Sand	Unpolluted
441	" " "	About ¾ mile of Staten Is. shore 500 ft. N.of Quarantine Station	Lat 40 36 50 Long 74 03 15	50	-	-	Silty Sand	Polluted
442	" " "	About 3000 ft. off Quarantine Station	Lat 40 36 47 Long 74 03 10	50	-	-	Sand Gravel	"
443	" " "	About ¾ mile off Quarantine Station	Lat 40 36 55 Long 74 02 56	50	-	-	" "	"

Examination of Deposits from the Harbor Bottom, The Narrows.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of water Feet	Color	Odor	Consistency	Opinion
444	May 7,1909	Narrows, Opposite Quarantine Station about midstream	Lat 40 36 58 Long 74 03 01	80	-	Oily	Sand Clay	Polluted
445	" " "	About 1000 ft. off Ft. Wadsworth	Lat 40 36 21 Long 74 03 10	80	Gray	-	Sub-Soil	"
446	" " "	" 1300 ft. "	Lat 40 36 25 Long 74 03 05	80	"	Oily	" "	"
447	" " "	About 3/8 mile off Ft. Wadsworth	Lat 40 36 25 Long 74 02 56	80	-	"	Sand	"
448	" " "	Midway between Ft.Wadsworth and Ft. Lafayette	Lat 40 36 27 Long 74 02 50	80	Brown	-	Sub-Soil	"
449	" " "	About ¼ mile off Ft.Lafayette	Lat 40 36 30 Long 74 02 41	80	"	Oily	Sludge clay	"
450	" " "	About 900 ft. west of buoy north of Ft.Lafayette	Lat 40 36 35 Long 74 02 37	80	-	"	" "	"
451	" " "	About 50 ft. east of buoy north of Ft. Lafayette	Lat 40 36 33 Long 74 02 26	10	Gray	"	Clay	"
452	" " "	About 2000 ft. off Quarantine pier	Lat 40 36 47 Long 74 03 16	75	-	"	Sand Clay	"

Ex. 98. P. 38

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued)

Examination No.	Date of collection	Location of Samples: Approximate	Exact				Depth of Water (feet)	Color	Odor	Consistency	Opinion
				°	'	"					
483	May 7 1909	About ½ mile east of Constable Point	Lat Long	40 74	39 04	1d 50	30	Gray		Subsoil	Polluted
484	"	About ½ mile northeast of Constable Point	Lat Long	40 74	39 04	25 42	30	"		Clay	"
485	"	About 7/8 mile northeast of Constable Point	Lat Long	40 74	39 04	33 35	30	"		"	"
486	"	About one mile northeast of Constable Point	Lat Long	40 74	39 04	38 28	30	"		"	"

Ex. 98. *P.* 39

Examination of Deposits from the Harbor Bottom, Newark Bay and Passaic River

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
457	May 8 1909	About 1/3 distance from Shooters Island toward Bergen Point Light	Lat 40 38 38 Long 74 09 13	20			Sand gravel	Unpolluted
458	"	Lower end of Newark Bay	Lat 40 38 58 Long 74 09 02	20		Oily	"	Polluted
459	"	On line draw of C.R.R.N.J. Bridge and bell buoy above, 1000 feet above bridge	Lat 40 39 25 Long 74 08 41	20		"	Sludge clay	"
460	"	Nearly halfway between draw of C.R.R.N.J. Bridge and bell buoy above	Lat 40 39 44 Long 74 08 25	20		"	Silt	"
461	"	Newark Bay at bell buoy above C.R.R.N.J. Bridge	Lat 40 40 10 Long 74 08 06	18		"	Sludge clay	"
462	"	Newark Bay near bell buoy above C.R.R.N.J. Bridge	Lat 40 40 37 Long 74 07 51	18		"	Silt	"
463	"	About 3000 feet south of buoy C.3	Lat 40 40 54 Long 74 07 41	12		"	Sludge clay	"
464	"	Newark Bay 200 feet east of can buoy No.3	Lat 40 41 22 Long 74 07 48	1f		"	"	"
465	"	Newark Bay at can buoy No. 4	Lat 40 41 35 Long 74 07 26	12		"	Sludge sand	"
466	"	About 1500 feet south of buoy N above Lehigh Valley Bridge	Lat 40 42 13 Long 74 07 11	12		"	"	Doubtful
467	"	At buoy N above Lehigh Valley Bridge	Lat 40 42 26 Long 74 07 11	12		"	"	Polluted
468	"	Newark Bay 2000 feet below bridge 100 feet off shore N.Y. and Newark	Lat 40 43 04 Long 74 07 21	18	Gray		Clay	Unpolluted

Examination of Deposits from the Harbor Bottom, Newark Bay and Passaic River. (Continued)

Examination No.	Date of collection	Location of Samples: Approximate	Exact	°	'	"	Depth of Water (feet)	Color	Odor	Consistency	Opinion
469	May 8, 1909	Passaic River 1000 feet above bridge, 60 feet off shore N.Y. and Newark	Lat Long	40 74	43 07	34 18	15	Gray	Oily	Sub-soil	Polluted
470	"	Passaic River 200 feet above Plank Road bridge, 90 feet off west shore	Lat Long	40 74	43 07	37 08	18			Sludge sand	"
471	"	Passaic River 1000 feet above Plank Road bridge midstream	Lat Long	40 74	44 07	08 02	18		"	Silty sand	"
472	"	Newark Bay near mouth of Hackensack River	Lat Long	40 74	43 06	03 39	18	"		Sandy clay	Doubtful
473	"	At mouth of Hackensack River 2300 feet below bridge	Lat Long	40 74	41 06	53 37	18	"		"	Polluted
474	"	At mouth of Hackensack River 2000 feet northeast of buoy 3	Lat Long	40 74	42 06	42 48	18	Black	"	Sludgy clay	"
475	"	Newark Bay 100 feet south of corner stake light	Lat Long	40 74	39 10	43 10	20	Gray	"	Sub-soil	"
476	"	Newark Bay 100 feet off S.W. corner of Shooters Island	Lat	40	38	37	16	"	"	clay	"
477	"	Newark Bay 150 feet off S.E. corner of Shooters Island	Lat Long	40 74	38 09	37 20	30	Black	"	"	"

FILMED BY STATE OF NEW JERSEY

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of Water (feet)	Color	Odor	Consistency	Opinion
478	May 14, 1909	Hudson River 300 feet off Pier 8, Hoboken.	Lat 40 44 16 Long 74 01 18	80	Gray	Oily	Sub-soil	Polluted
479	"	Hudson River 900 feet out from 8, Hoboken	Lat 40 44 19 Long 74 01 25	60	"	"	"	"
480	"	Midstream opposite Christopher Street, Manhattan	Lat 40 43 56 Long 74 01 18	40	"	"	"	Doubtful
481	"	1200 feet off Pier 45, Hudson River, Manhattan	Lat 40 43 57 Long 74 00 50	60	"		clay	
482	"	About 600 feet off Pier 44 Hudson River, Manhattan	Lat 40 43 56 Long 74 00 50	50			sand gravel	Polluted
483	"	600 feet out from Erie Pier A, Hoboken	Lat 40 45 31 Long 74 01 13	35	Brown		clay	Doubtful
484	"	Opposite West 12th Street, Manhattan, 1800 feet off New Jersey Shore	Lat 40 45 35 Long 74 01 00	35	"		"	Unpolluted
485	"	2800 feet off West 33rd St., Manhattan	Lat 40 45 40 Long 74 00 49	60	"		"	Doubtful
486	"	1800 feet off West 33rd St., Manhattan	Lat 40 45 36 Long 74 00 37	60	Gray		"	Unpolluted
487	"	800 feet off West 33rd St., Manhattan	Lat 40 45 30 Long 74 00 28	40			sand gravel	"
488	"	Opposite West 72nd St., Manhattan, 1000 feet off New Jersey shore	Lat 40 47 07 Long 73 59 53	75	"		sub-soil	Polluted
489	"	2430 feet off West 94th St., Manhattan	Lat 40 47 08 Long 73 59 39	60	"		"	
490	"	Midstream opposite West 72nd St., Manhattan	Lat 40 47 01 Long 73 59 42	60	"	"	"	
491	"	1200 feet from 72nd St., Pier, Manhattan, Hudson River	Lat 40 46 58 Long 73 59 30	45	"		"	Unpolluted

Ex. 98. P. 42

Examination of Deposits from the Harbor Bottom, Hudson River. (Continued)

Examination No.	Date of collection	Location of Samples	Exact				Depth of Water (feet)	Color	Odor	Consistency	Opinion
				°	'	"					
492	May 14, 1909	900 feet from 72nd St., Pier, Manhattan, Hudson River	Lat Long	40 73	46 59	57 29	40	Gray		Clay	Polluted
493	"	300 feet from 72nd St., Pier, Manhattan, Hudson River	Lat Long	40 73	46 59	54 23	35	Black	Oily	Sludge sub-soil	"
494	May 15, 1909	Opposite W. 96th St. Manhattan, 500 feet off New Jersey shore	Lat Long	40 73	48 59	10 25	15	Gray	"	Sub-soil	Doubtful
495	"	Opposite W. 96th St. Manhattan, 1500 feet off New Jersey shore	Lat Long	40 73	48 59	04 13	20	"	"	"	"
496	"	Midstream opposite W. 96th St. Manhattan	Lat Long	40 73	48 59	00 03	50	"	"	"	Polluted
497	"	1400 feet off Pier W.96th St. Manhattan	Lat Long	40 73	47 58	55 53	50	Brown		"	"
498	"	300 feet off Pier W. 96th St. Manhattan	Lat Long	40 73	47 58	50 40	40	"		Clay	Doubtful
499	"	300 feet off West shore Opposite Ft. Washington Point	Lat Long	40 73	51 57	07 32	12	Gray Yellow		"	Unpolluted
500	"	Opposite Ft. Washington Point about 1/3 distance from west shore	Lat Long	40 73	51 57	05 21	20	Gray Yellow		"	Doubtful
501	"	Opposite Ft. Washington Point about 2/3 across from west shore	Lat Long	40 73	51 57	03 05	45	Black Yellow		"	"
502	"	400 feet out from Ft. Washington Point	Lat Long	40 73	51 56	02 56	80			Rock	

Examination of Deposits from the Harbor Bottom, Lower Bay.

Examination No.	Date of collection	Location of Samples		Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram
		Approximate	Exact ° ' "						
503	May 17 1909	By Gas buoy S 2, near Coney Is.	Lat 40 34 00 Long 73 59 20	20	Black		Mud	Unpolluted	1,400,000
504	"	About 3/4 mile south of buoy S2, off Coney Is.	Lat 40 33 25 Long 73 59 25	15	Brown		Sand	Unpolluted	2,400
506	"	About 1 mile south of buoy S2, off Coney Is.	Lat 40 33 10 Long 73 59 30	15	Brown		Sand	Unpolluted	1,200
507	"	About 1 1/2 miles south of buoy S 2, off Coney Island	Lat 40 32 45 Long 73 59 40	15	Brown		Sand	Unpolluted	800
508	"	About 7/8 mile north of A C buoy 14	Lat 40 32 10 Long 73 59 35	20	Brown		Sand	Unpolluted	1,200
509	"	About 3/8 mile north of A C buoy 14	Lat 40 31 45 Long 73 59 35	20	Brown		Sand	Doubtful	1,400
510	"	1000 feet N.-N.W. of AC buoy No. 12	Lat 40 31 15 Long 73 59 10	20	Brown		Sand	Unpolluted	2,200
511	"	50 feet N. of A.C. buoy No. 12	Lat 40 31 05 Long 73 59 05	15	Brown		Sand	Unpolluted	900
513	May 18 1909	In Ambrose Channel 100 feet south of A C buoy No. 12	Lat 40 31 00 Long 73 59 00	40	Gray		Sand	Unpolluted	1,900
514	"	Midway between bucys A C 12 and N. B. 2	Lat 40 30 10 Long 73 58 40	20	Brown		Sand	Unpolluted	
515	"	100 feet north of N. B. buoy 2	Lat 40 29 30 Long 73 58 25	20	Brown		Sand	Unpolluted	1,200
516	"	100 feet south of N. B. buoy 2 Main Channel	Lat 40 29 25 Long 73 58 25	35	Brown		Sand	Unpolluted	
517	"	100 feet south of buoy N 2 1/2 Main Channel	Lat 40 29 10 Long 73 59 20	40	Brown		Sand	Unpolluted	2,400

Examination of Deposits from the Harbor Bottom, Lower Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram
518	May 18 1909	100 feet south of buoy E 4 Main Channel	Lat 40 29 00 Long 74 00 20	40	Brown		Sand	Unpolluted	
519	"	100 feet south of buoy E 6 Main Channel	Lat 40 29 00 Long 74 00 40	50	Brown		Sand	Unpolluted	1,400
520	"	100 feet south of buoy E 8 Main Channel	Lat 40 28 45 Long 74 01 20	40	Brown		Sand	Unpolluted	
521	"	100 feet south of buoy E 10 Main Channel	Lat 40 28 35 Long 74 02 05	40	Brown & Black		Sand	Unpolluted	50,000
522	"	100 feet south of buoy E 12 Main Channel	Lat 40 28 40 Long 74 02 40	35	Gray		Sand mud	Polluted	
523	"	100 feet west of buoy NC 2 Main Channel	Lat 40 29 10 Long 74 02 45	35	Gray		Mud	Polluted	600,000
524	"	100 feet west of buoy NC 4 Main Channel	Lat 40 29 40 Long 74 02 40	35	Gray		Mud	Polluted	
525	"	100 feet west of buoy NC 6 Main Channel	Lat 40 30 10 Long 74 02 40	35	Gray		Mud	Polluted	1,200,000
526	"	100 feet west of buoy NC 8 Main Channel	Lat 40 30 40 Long 74 02 35	35	Gray		Mud sand	Polluted	
527	"	100 feet west of buoy N Main Channel	Lat 40 31 15 Long 74 02 30	35	gray		Mud	Polluted	1,800,000
528	"	100 feet east of buoy C 9 Main Channel	Lat 40 32 00 Long 74 02 25	35	Gray		Mud	Polluted	
529	"	100 feet east of buoy C 9 1/2 Main Channel	Lat 40 33 00 Long 74 02 25	35	Gray		Mud sand	Polluted	2,400,000
530	"	100 feet east of buoy 11 Main Channel, Lower Bay	Lat 40 34 05 Long 74 02 40	40	Gray		Mud sand	Douttful	
531	"	50 feet east of Craven Shoal buoy	Lat 40 35 05 Long 74 02 30	50	Gray		Mud	Doubtful	4,800,000

Examination of Deposits from the Harbor Bottom, Lower Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth of water (feet)	Color Odor	Consistency	Opinion	Bacteria per gram
532	May 19 1909	500 feet west of Craven Shoal buoy	Lat 40 35 40 Long 74 02 35	30	Gray	Mud	Polluted	1,200,000
533	"	500 feet off flagstaff South Beach, S. I.	Lat 40 35 00 Long 74 04 20	10	Gray	Sand mud	Doubtful	
534	"	About 1 1/4 miles west of Swinburne Island	Lat 40 34 15 Long 74 04 20	15	Gray	Mud	Unpolluted	800,000
535	"	On line West Bank light and Elm Tree Beacon, 1 mile off S. I. shore	Lat 40 33 20 Long 74 04 50	15	Gray	Mud	Doubtful	
536	"	About 2 1/4 miles west of West Bank light	Lat 40 32 45 Long 74 05 00	15	Gray	Mud	Doubtful	1,100,000
537	"	About 1 1/2 miles northeast of Old Orchard Shoal light	Lat 40 32 00 Long 74 05 30	15	Brown & black	Sand	Polluted	
538	"	About 3/4 mile northeast of Old orchard Shoal light	Lat 40 31 30 Long 74 05 40	15	Brown & black	Sand	Polluted	600,000
539	"	100 feet north of Old Orchard light	Lat 40 30 50 Long 74 05 50	20	Brown & black	Sand	Unpolluted	
540	"	100 feet north of buoy "cable E & W" farthest north, Lower Bay	Lat 40 30 05 Long 74 06 15	20	Gray	Mud	Doubtful	600,000
541	"	100 feet north of buoy "cable E & W" farthest south, Lower Bay	Lat 40 29 25 Long 74 06 30	25	Gray	Mud	Doubtful	
542	"	200 feet south of buoy S.I.W. Lower Bay	Lat 40 28 40 Long 74 06 45	15	Brown black	Sand	Unpolluted	140,000

Examination of Deposits from the Harbor Bottom, Lower Bay.

Examination No.	Date of Collection	Location of Samples: Approximate	Exact	Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram
543	May 19 1909	Halfway between Pt. Comfort Beacon and buoy S.1.W.	Lat 40 27 50 Long 74 06 52	18	Brown	Sand	Unpolluted		4,800
544	"	500 feet south of buoy 1 1/2 off Seguine Pt.	Lat 40 30 20 Long 74 10 45	18	Gray	Mud	Unpolluted		
545	"	500 feet south of buoy N off Seguine Pt.	Lat 40 30 00 Long 74 09 48	20	Gray	Mud	Unpolluted		400,000

Examination of Deposits from the Harbor Bottom. East River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth in feet Water	Color	Odor	Constituents	Opinion
846	May 29, 1909	Off spindle light at buoy No. 4 Sunken Meadow	Lat 40 47 24 Long 73 54 51	90	Brown	-	Gravel	Unpolluted
847	"	At buoy No. 7 off Lawrence Point	Lat 40 47 34 Long 73 54 31	60	Brown	-	Sand	Unpolluted
848	"	At buoy No. 8 off Lawrence Point	Lat 40 47 42 Long 73 54 19	60	-	-	Rock	-
849	"	Midway between buoy 8 and light on E.Brother Is.	Lat 40 47 50 Long 73 54 09	40	Black	Oily	Sludge	Polluted
850	"	At buoy #3 E of E.Brother Is.	Lat 40 47 56 Long 73 53 48	60	Black	Oily	Sludge Clay	Polluted
851	"	At red buoy 2 1/2 off E. Brother Is.	Lat 40 48 17 Long 73 53 40	60	Black	Oily	Sludge Clay	Polluted
854	June 8, 1909	1800 feet out from Riker's Is. light	Lat 40 48 07 Long 73 53 30	40	-	Oily	Sand gravel	Polluted
855	"	In line Riker's Is. light and Hunts Pt. 1/3 distance	Lat 40 47 57 Long 73 53 02	60	-	-	Rock	-
856	"	In line Riker's Is. light and Hunts Pt. 2/3 distance from light	Lat 40 48 01 Long 73 52 48	78	-	-	Rock	-
857	"	900 feet off Hunts Point in range with Rikers Is. light	Lat 40 48 02 Long 73 52 36	60	Black	Oily	Sludge	Polluted
858	"	Red spar buoy No. 2 off Hunts Point	Lat 40 48 01 Long 73 52 26	50	Gray	Oily	Clay	Polluted
859	"	100 ft. from red spar buoy No. 2 off Hunts Point	Lat 40 47 59 Long 73 52 26	40	Gray	Oily	Sub-soil	Polluted
860	"	1300 feet north of Rikers Island	Lat 40 47 48 Long 73 52 08	40	Black	Oily	Sludge	Polluted
861	"	1800 feet north east of Rikers Island	Lat 40 47 38 Long 73 52 00	60	Black	Oily	Sludge Clay	Polluted

PEOPLE OF STATE OF NEW YORK VS STATE OF NEW JERSEY. 2830

Examination of Deposits from the Harbor Bottom. Kmot River.

Examination No.	Date of collection			Depth in feet Water	Color	Odor	Consistency	Opinion
862	June 8, 1909	2400 feet off ferry slip College Point	Lat 40 47 30 Long 73 51 50	18	Black	Oily	Sludge clay	Polluted
863	"	2000 feet out from ferry slip College Pt. in line with red spar buoy Pt. Hunte Point	Lat 40 47 24 Long 73 51 50	80	Gray	Oily	Clay	Polluted
864	"	800 feet out from ferry slip College Pt. in line with red spar buoy Pt Hunte Point	Lat 40 47 18 Long 73 51 40	40	Gray	Oily	Clay	Polluted
865	"	In bay between ferry slip College Point and N.E. point of College Point	Lat 40 47 23 Long 73 51 23	8	Gray	Oily	Clay	Polluted
866	"	At black spar buoy #1 off Clauson Point	Lat 40 47 33 Long 73 51 08	18	-	-	Sludge	Polluted
867	"	1000 feet spar buoy #1 towards Clauson Point	Lat 40 48 03 Long 73 51 08	60	Black	Oily	Sludge	Polluted
868	"	1000 feet off Clauson Point Casino dock	Lat 40 48 08 Long 73 51 08	60	Black	Oily	Sludge clay	Polluted
869	"	1000 feet out from trolley dock, Clauson Point	Lat 40 48 11 Long 73 50 48	60	-	Oily	Silt sand	Polluted
870	"	Midway between Pallman Is. dock and Clauson Pt.	Lat 40 48 06 Long 73 50 40	70	-	-	Rock	-
871	"	800 feet off Pallman Is. block	Lat 40 47 54 Long 73 50 27	28	Gray	-	Clay	Polluted
872	June 7, 1909	1000 feet off Pallman Is. dock	Lat 40 48 00 Long 73 50 16	60	Gray	Oily	Clay	Polluted
873	"	Midway between Old Ferry Point and Whitestone light	Lat 40 48 10 Long 73 50 10	70	Gray	Oily	Clay	Polluted

Ex. 98, p. 49

Examination of Deposits from the Harbor Bottom. East River.

Examination Number	Date of collection	Location of Samples			Depth in feet Water	Color	Odor	Consistency	Opinion
		Approximate	Exact						
574	June 7, 1909	1000 feet off Old Ferry Pt. in line with Whitestone light	Lat 40 48 14 Long 73 49 43		90	Gray	Oily	Clay	Polluted
575	" " "	Half way between Whitestone Point and Old Ferry Point	Lat 40 48 10 Long 73 49 33		70	Black	Oily	Sludge clay	Polluted
576	" " "	About 2/3 way across from Old Ferry Point to Whitestone light	Lat 40 48 07 Long 73 49 26		80	Black	Oily	Sludge clay	Polluted
577	" " "	500 feet off Whitestone light in line with Old Ferry Point	Lat 40 48 04 Long 73 49 17		70	Gray	Oily	Clay	Polluted
578	" " "	1600 feet off Whitestone Point	Lat 40 48 18 Long 73 49 14		70	Gray	Oily	Clay	Polluted
579	" " "	2300 feet off Whitestone Point	Lat 40 48 24 Long 73 49 15		90	Gray	Oily	Clay	Polluted
580	" " "	3000 feet off Whitestone Point	Lat 40 48 31 Long 73 49 17		10	Gray	Oily	Clay	Polluted
581	" " "	1000 feet off shore from cupola in range with Whitestone light	Lat 40 48 36 Long 73 49 17		70	Gray	-	Clay	Unpolluted

Ex. 98. P. 50.

Examination of Deposits from the Harbor Bottom, Long Island Sound.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
582	June 8, 1909	1000 feet off Whitestone light in line with Ft. Schuyler light	Lat 40 48 04 Long 73 48 59	50	Gray	Oily	Sub-soil	Polluted
583	"	2200 feet off Whitestone light in line with Ft. Schuyler light	Lat 40 48 06 Long 73 48 44	50	Gray	Oily	Sub-soil	Polluted
584	"	3100 feet off Whitestone light in line with Ft. Schuyler light	Lat 40 48 08 Long 73 48 32	50	Gray	Oily	Sub-soil	Polluted
585	"	4000 feet off Whitestone light in line with Ft. Schuyler light	Lat 40 48 10 Long 73 48 20	40	Gray	Oily	Sub-soil	Polluted
586	"	3200 feet off Ft. Schuyler light in line with Whitestone light	Lat 40 48 11 Long 73 48 15	50	Gray	Oily	Sub-soil	Polluted
587	"	2800 feet off Ft. Schuyler light in line with Whitestone light	Lat 40 48 12 Long 73 48 03	50	Gray	Oily	Sub-soil	Polluted
588	"	500 feet off Ft. Schuyler light in range with Whitestone light	Lat 40 48 16 Long 73 47 42	50	Gray	-	Clay	Polluted
589	"	From Ft. Schuyler light to Stepping Stones light 1000 feet off shore	Lat 40 48 32 Long 73 47 21	30	-	-	Clay	Unpolluted
590	"	2500 feet from Ft. Schuyler light in line with Stepping Stones light	Lat 40 48 44 Long 73 47 10	50	-	-	Clay sand	Unpolluted
591	"	4300 feet from Ft. Schuyler light in line with Stepping Stones light	Lat 40 48 89 Long 73 46 57	50	Gray	-	Clay	Unpolluted
592	"	1500 feet from Stepping Stones light in line with Ft. Schuyler light	Lat 40 49 15 Long 73 46 42	35	Brown	-	Clay	Unpolluted
593	"	1000 feet from Stepping Stones light in line with City Is.	Lat 40 49 35 Long 73 46 30	40	-	-	Sand gravel	Unpolluted
594	"	2000 feet from Stepping Stones light in line with City Is.	Lat 40 49 50 Long 73 46 40	75	Black	H_2S	Clay	Unpolluted
595	"	3800 feet from Stepping Stones light in line with City Is.	Lat 40 50 00 Long 73 46 40	80	Gray	H_2S	Sub-soil	Unpolluted
596	"	100 feet off west point of City Is	Lat 40 50 15 Long 73 46 50	25	-	-	Sludge clay	Doubtful
597	"	700 feet west of Hawkins dock, south side of City Is.	Lat 40 50 25 Long 73 46 40	20	-	-	-	
598	"	800 feet off Hawkins dock south side, City Is.	Lat 40 50 35 Long 73 46 40	20	Gray	-	Clay	Unpolluted

Ex. 98. P. 51.

STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3839

Examination of Deposits from the Harbor Bottom — Lower Bay

Examination No.	Date of Collection	Location of Samples: Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion
599	June 12,09	300 feet off U.S.R.R. Cook below Sandy Hook light	Lat 40 26 50 Long 74 00 18	6	Brown	-	Clay	Unpolluted
600	"	Along west shore Sandy Hook	Lat 40 27 10 Long 74 00 25	5	White	-	Sand	"
601	"	Along west shore Sandy Hook	Lat 40 27 20 Long 74 00 35	5	White	-	"	"
602	"	In cove south of U.S.R.R. dock-Sandy Hook	Lat 40 27 45 Long 73 59 55	15	-	-	Silty sand	"
603	"	At spar off S.Beacon light-Sandy Hook	Lat 40 27 40 Long 74 00 38	12	White	-	Sand	"
604	"	1000 feet off dock north of Life Saving Station	Lat 40 27 50 Long 74 00 38	16	-	-	Sand	"

Examination of Deposits from the Harbor Bottom. Eastchester Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
			° ' "					
605	June 14, 1909	200 off Oil dock, City Island	Lat 40 50 30 Long 73 47 20	18	Gray	-	Clay	Unpolluted
606	"	2300 feet west of City Island	Lat 40 50 28 Long 73 47 40	18	Gray	-	Clay	Unpolluted
607	"	3800 feet west of City Island	Lat 40 50 20 Long 73 48 00	10	Gray	H_2S	Clay	Unpolluted
608	"	4500 feet west of City Island	Lat 40 50 18 Long 73 49 05	12	Gray	H_2S	Clay	Unpolluted
609	"	5000 feet west of City Island	Lat 40 50 18 Long 73 48 20	18	Gray	H_2S	Clay	Unpolluted
610	"	6000 feet west of City Island	Lat 40 50 10 Long 73 48 28	12	Gray	H_2S	Clay	Unpolluted
611	"	About 1 3/8 miles west of City Island 1000 feet off Westchester shore	Lat 40 50 05 Long 73 48 40	12	Gray	H_2S	Clay	Unpolluted
612	"	About 3/8 mile off Westchester shore	Lat 40 49 50 Long 73 48 20	12	Gray	H_2S	Clay	Unpolluted
613	"	About 1900 feet off Westchester shore	Lat 40 49 20 Long 73 47 55	12	Gray	H_2S	Clay	Unpolluted
614	"	About 900 feet off Westchester shore near Throgs Neck	Lat 40 49 00 Long 73 47 40	12	Gray	-	Clay	Unpolluted

Examination of Deposits from the Harbor Bottom. Little Neck Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
			° ' "					
615	June 23, 1909	In Little Neck Bay	Lat 40 47 30 Long 73 45 30	8	Black	-	Mud	Unpolluted
616	"	LittleNeck cove at S.E. extremity of Little Neck Bay	Lat 40 47 00 Long 73 45 00	8	Black	-	Mud	Polluted
617	"	Mouth of Little Neck Creek	Lat 40 46 00 Long 73 45 30	9	Black	-	Mud	Unpolluted
618	"	In Little Neck Bay	Lat 40 46 30 Long 73 45 30	8	Black	-	Mud	Unpolluted
619	"	In Little Neck Bay, near Willet's Point	Lat 40 46 30 Long 73 45 30	8	Black	-	Mud	Unpolluted
620	"	At mouth of Little Neck Bay	Lat 40 46 00 Long 73 45 30	8	Black	-	Mud	Unpolluted
621	"	At mouth of Little Neck Bay near Willet's Point	Lat 40 47 40 Long 73 46 00	9	Black	-	Mud	Unpolluted

Examination of Deposits from the Harbor Bottom. Knot River.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
622	Jan.28 1909	100 feet off dock on Throgs Neck	Lat. 40 46 19 Long 73 47 44	30	Black	-	Mud	Unpolluted
623	"	1/4 way across river from Throgs Neck	Lat 40 46 12 Long 73 47 48	30	Black	-	Mud	Polluted
624	"	3/4 way across river from Throgs Neck	Lat 40 47 56 Long 73 47 56	70	Black	-	Mud	Polluted
625	"	100 feet off dock at Beechhurst, Whitestone	Lat 40 47 47 Long 73 48 00	10	-	-	Mud	Doubtful

Examination of Deposits from the Harbor Bottom. Jamaica Bay

Examination No.	Date of Collection	Location of Samples Approximate	Exact o ' "	Depth of Water feet	Color	Odor	Consistency	Opinion	Bacteria per gram
626	June 29,09	Jamaica Bay,100 feet off dock Belle Harbor,Beach channel	Lat 40 34 55 Long 73 51 05	10	Gray	-	Sand	Unpolluted	12,000
627	"	Jamaica Bay,100 feet above drawbridge at Hammels	Lat 40 35 45 Long 73 48 50	10	"	-	Silty sand	"	900,000
628	"	30 feet off foot Bayswater Ave. Far Rockaway	Lat 40 36 30 Long 73 46 15	.6	"	-	Clay gravel	"	700,000
629	June 30,09	Jamaica Bay, At bridge Norton's Creek head of Bay Edgemere	Lat 40 36 00 Long 73 46 10	10	"	-	Clay	Doubtful	1,000 000
630	"	100 feet off shore opposite Arverne Sta.Jamaica Bay	Lat 40 35 40 Long 73 47 25	4	Black	-	"	Polluted	6,000,000
631	"	Jamaica Bay,1000 feet out from Arverne Sta.	Lat 40 36 05 Long 73 47 20	4	"	-	"	Doubtful	1,000,000
632	"	Jamaica Bay, Cross Channel off Arverne	Lat 40 35 50 Long 73 48 25	8	Gray	-	"	"	900,000
633	"	Jamaica Bay,creek at foot of Pleasant Ave, Arverne	Lat 40 35 35 Long 73 48 25	8	"	-	Sand clay	"	1,200,000
634	"	Cross Creek along shore near Park Ave. Arverne	Lat 40 35 30 Long 73 48 20	8	-	-	-	Polluted	2,000,000
635	"	Jamaica Bay 100 feet off foot of Bannister Ave. Arverne	Lat 40 35 45 Long 73 48 15	6	Black	-	Clay	"	6,000,000
636	"	Yard of house near foot of Pleasant Ave.	Lat 40 35 35 Long 73 48 10	3	Gray	-	"	Doubtful	250,000
637	July"1,09	Jamaica Bay, mouth of Fresh Creek	Lat 40 38 30 Long 73 52 55	3	"	-	"	Unpolluted	900,000
638	"	Jamaica Bay half way up Fresh Creek	Lat 40 38 50 Long 73 53 20	3	Black	-	"	"	1,200,000

Examination of Deposits from the Harbor Bottom Jamaica Bay

Examination No.	Date of Collection	Location of Samples: Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion	Bacteria per gram.
639	July 1,09	Second creek midway between mouth and sewer	Lat 40 39 05 Long 73 53 00	4	-	-	Sludge	Polluted	12,000,000
640	"	At mouth of Second creek	Lat 40 38 55 Long 73 52 40	4	Black	-	Clay	"	9,000,000
641	"	Jamaica Bay 500 feet off mouth of Second Creek	Lat 40 38 35 Long 73 52 25	6	"	-	Clay gravel	"	1,200,000
642	"	Jamaica Bay 500 feet off mouth of Fresh Creek	Lat 40 38 25 Long 73 52 30	6	"	-	Sandy clay	"	900,000
643	"	Jamaica Bay 500 feet off shore at Sandy Bay, north of Canarsie	Lat 40 37 50 Long 73 53 05	6	"	-	Clay	"	750,000
644	"	Jamaica Bay Creek running through Canarsie	Lat 40 39 15 Long 73 54 00	6	"	-	"	"	700,000
645	"	Jamaica Bay 100 feet off main landing Canarsie	Lat 40 37 40 Long 73 53 15	8	"	-	"	Unpolluted	120,000
646	"	Half way across Rockaway Inlet	Lat 40 34 15 Long 73 53 55	40	-	-	-	-	8,000

Examination of Deposits from the Harbor Bottom. Hudson River.

Examination No.	Date of collection	Location of Samples Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
647	July 7, 1909	Hudson River 100 feet off Mt. St. Vincent Station	Lat 40° 54' 50" Long 73 54 45	10	Gray	-	Clay	Polluted
648	"	Hudson River 200 feet off Ludlow Station	Lat 40 55 27 Long 73 54 30	10	Gray	-	Clay	Polluted
649	"	Hudson River 200 feet off Federal Sugar Plant	Lat 40 55 45 Long 73 54 23	10	Gray	-	Clay	Polluted
650	"	200 feet off recreation pier Yonkers	Lat 40 56 07 Long 73 54 20	30	Black	Oily	Clay	Polluted
651	"	Hudson River 200 feet off Spuyten Duyvil draw-bridge	Lat 40 52 43 Long 73 55 37	30	-	-	Sand	Doubtful

Ex. 98. p.58

Examination of Deposits from the Harbor Bottom Gravesend Bay

Examination No.	Date of Collection	Location of Samples Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion
652	July 9,09	Gravesend Bay foot of 22d St. Coney Island	Lat 40 34 45 Long 73 59 26	4	Black	Putrid	Sludge	Polluted
653	"	Gravesend Bay foot of 24th St. Coney Island	Lat 40 34 44 Long 73 59 33	4	"	Foul	Sand	"
654	"	Gravesend Bay by the breakwater north of entrance to Coney Island	Lat 40 35 00 Long 73 59 30	6	-	-	"	Unpolluted

Ex. 98. p.59

Examination of Deposits from the Harbor Bottom. Upper Bay.

Examination No.	Date of collection	Location of Samples Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
655	July 15, 1909	150 feet off Greenville shore	Lat 40 41 34 Long 74 04 56	4	Gray	-	Sub-soil	Unpolluted
656	"	200 feet off Greenville shore	Lat 40 41 31 Long 74 04 50	4	Gray	-	Sub-soil	Unpolluted
657	"	300 feet off Greenville shore	Lat 40 41 29 Long 74 04 43	4	Gray	-	Sub-soil	Unpolluted
658	"	400 feet off Greenville shore	Lat 40 41 25 Long 74 04 40	4	Gray	-	Clay	Unpolluted
659	"	500 feet off Greenville shore	Lat 40 41 20 Long 74 04 36	4	Gray	-	Clay	Unpolluted
660	"	600 feet off Greenville shore	Lat 40 41 17 Long 74 04 27	4	Gray	-	Clay	Unpolluted
661	"	700 feet off Greenville shore	Lat 40 41 14 Long 74 04 18	4	Gray	-	Clay	Unpolluted
662	"	1000 feet off Greenville shore	Lat 40 41 06 Long 74 04 04	4	Gray	-	Clay	Unpolluted
663	"	1200 feet off Greenville shore	Lat 40 40 58 Long 74 03 49	4	Gray	-	Clay	Unpolluted
664	"	100 feet off Greenville shore	Lat 40 41 22 Long 74 05 08	4	Gray	-	Clay	Unpolluted
665	"	200 feet off Greenville shore	Lat 40 41 19 Long 74 05 00	4	Gray	-	Clay	Unpolluted
666	"	300 feet off Greenville shore	Lat 40 41 12 Long 74 04 53	4	Gray	-	Clay	Unpolluted
667	"	500 feet off Greenville shore	Lat 40 41 07 Long 74 04 44	4	Gray	-	Clay	Unpolluted
668	"	700 feet off Greenville shore	Lat 40 41 00 Long 74 04 36	4	Gray	-	Clay	Unpolluted
669	"	Near end of P.R.R. docks, Greenville	Lat 40 40 52 Long 74 04 27	4	Gray	-	Clay	Unpolluted
670	"	At the end of P.R.R. docks, Greenville	Lat 40 40 49 Long 74 04 19	20	Gray	-	Clay	Unpolluted

Examination of Deposits from the Harbor Bottom. Upper Bay.

Registration No.	Date of collection	Location of Samples Approximate	Exact	Depth in feet Water	Color	Odor	Consistency	Opinion
671	July 10, 1909	800 feet off Bayonne shore at Pamrapo	Lat 40 40 26 Long 74 06 08	6	Gray	-	Sub-soil	Unpolluted
672	"	1000 feet off Bayonne shore at Pamrapo	Lat 40 40 22 Long 74 06 26	6	Gray	-	Sub-soil	Unpolluted
673	"	2000 feet off Bayonne shore at Pamrapo	Lat 40 40 17 Long 74 05 49	6	Black	-	Sub-Soil	Unpolluted
674	"	2800 feet off Bayonne shore at Pamrapo	Lat 40 40 14 Long 74 05 42	6	Gray	-	Sub-soil	Unpolluted
675	"	3000 feet off Bayonne shore at Pamrapo	Lat 40 40 12 Long 74 05 38	6	Gray	-	Sub-soil	Unpolluted
676	"	4000 feet off Bayonne shore at Pamrapo	Lat 40 40 07 Long 74 05 24	6	Gray	-	Sub-soil	Unpolluted
677	"	5000 feet off Bayonne shore at Pamrapo	Lat 40 40 02 Long 74 05 13	6	Black	-	Sub-soil	Unpolluted
678	"	6000 feet off Bayonne shore at Pamrapo	Lat 40 39 57 Long 74 04 58	6	Gray	-	Sub-soil	Unpolluted
679	"	7000 feet off Bayonne shore at Pamrapo	Lat 40 39 48 Long 74 04 46	6	Black	Oily	Sub-soil	Unpolluted
680	"	7500 feet off Bayonne shore at Pamrapo	Lat 40 39 43 Long 74 04 36	6	Black	Oily	Sub-soil	Unpolluted
681	"	1000 feet off Bayonne shore at Pamrapo	Lat 40 39 35 Long 74 04 19	10	Black	Oily	Clay	Doubtful
682	"	100 feet off Bayonne shore at Pamrapo	Lat 40 40 18 Long 74 06 22	6	Gray	-	Sub-soil	Unpolluted
683	"	1000 feet off Bayonne shore at Pamrapo	Lat 40 40 10 Long 74 06 18	6	Gray	Oily	Sub-soil	Unpolluted
684	"	3000 feet off Bayonne shore at Pamrapo	Lat 40 40 10 Long 74 06 01	6	Black	-	Sub-soil	Unpolluted
685	"	3000 feet off Bayonne shore at Pamrapo	Lat 40 40 00 Long 74 05 50	6	Gray	-	Sub-soil	Unpolluted

Examination of Deposits from the Harbor Bottom. Upper Bay.

Examination No.	Date of collection	Location of Samples Approximate	Exact ° ' "	Depth in feet Water	Color	Odor	Consistency	Opinion
686	July 19, 1909	4000 feet off Bayonne shore at Pamrapo	Lat 40 39 57 Long 74 08 40	6	Gray	-	Sub-soil	Unpolluted
687	"	5000 feet off Bayonne shore at Pamrapo	Lat 40 39 52 Long 74 08 32	6	Gray	Oily	Sub-soil	Unpolluted
688	"	6000 feet off Bayonne shore at Pamrapo	Lat 40 39 47 Long 74 08 22	6	Gray	-	Sub-soil	Unpolluted
689	"	7000 feet off Bayonne shore at Pamrapo	Lat 40 39 48 Long 74 08 12	6	Gray	Oily	Sub-soil	Unpolluted
690	"	8000 feet off Bayonne shore at Pamrapo	Lat 40 39 36 Long 74 08 02	6	Gray	Oily	Sub-soil	Unpolluted
691	"	8000 feet west of Robbins Reef	Lat 40 39 19 Long 74 04 50	10	Gray	Oily	Sub-soil	Doubtful
692	July 21, 1909	Off the end of P. R. R. dock at Greenville	Lat 40 40 27 Long 74 04 08	10	Gray	-	Silty sand	Unpolluted
693	"	2000 feet off P. R. R. dock at Greenville	Lat 40 40 28 Long 74 03 48	6	Gray	-	Sub-soil	Doubtful
694	"	2800 feet off P. R. R. dock at Greenville	Lat 40 40 19 Long 74 03 48	8	Gray	-	Sub-soil	Unpolluted
695	"	2600 feet off P. R. R. dock at Greenville	Lat 40 40 13 Long 74 03 47	10	-	-	Sandy Clay	Polluted
696	"	3000 feet off P. R. R. dock at Greenville	Lat 40 40 07 Long 74 03 41	10	Gray	-	Sub-soil	Polluted
697	"	4000 feet off P. R. R. dock at Greenville	Lat 40 40 08 Long 74 03 38	10	Gray	-	Sandy Clay	Polluted
698	"	800 feet west of Robbins Reef	Lat 40 39 26 Long 74 04 08	10	-	-	Rock	
699	"	1000 feet northwest of Robbins Reef	Lat 40 39 29 Long 74 04 04	10	Gray	-	Sub-soil	Unpolluted
700	"	2000 feet northeast of Robbins Reef	Lat 40 39 45 Long 74 04 16	10	Gray	Oily	Clay	Unpolluted
701	"	3000 feet northeast of Robbins Reef	Lat 40 39 51 Long 74 04 30	10	Gray	Oily	Clay	Unpolluted

Examination of Deposits from the Harbor Bottom. Upper Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact				Depth in feet Water	Color	Odor	Consistency	Opinion
				°	'	"					
702	July 21, 1909	3500 feet northwest of Robbins Reef	Lat	40	39	57	10	Gray	Oily	Clay	Unpolluted
			Long	74	04	22					
703	"	4000 feet northwest of Robbins Reef	Lat	40	40	02	10	Gray	-	Clay	Unpolluted
			Long	74	04	25					
704	"	4500 feet northwest of Robbins Reef	Lat	40	40	07	10	Gray	Oily	Clay	Unpolluted
			Long	74	04	25					
705	"	5000 feet northwest of Robbins Reef	Lat	40	40	15	8	Gray	-	Clay	Unpolluted
			Long	74	04	28					
706	"	6000 feet northwest of Robbins Reef	Lat	40	40	20	6	Gray	-	Clay	Unpolluted
			Long	74	04	33					
707	"	At south side of P.R.R. dock Reef	Lat	40	40	31	5	Gray	-	Clay	Unpolluted
			Long	74	04	42					

PEOPLE OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 3851

Examination of Deposits from the Harbor Bottom Lower Bay

Examination No.	Date of Collection	Location of Samples Approximate	Exact	Depth of water feet	Color	Odor	Consistency	Opinion	Bacteria per gram
708	July 21,09	Sandy Hook near Shrewsbury River	Lat 40 47 50 Long 74 01 25	30	Black	Marshy	Clay	Polluted	60,000
709	"	Shrewsbury River at Spermaceti Cove	Lat 40 24 55 Long 73 59 35	8	Brown	None	Sand gravel	Unpolluted	4,800
710	"	Shrewsbury River at Seabright	Lat 40 21 55 Long 73 58 40	8	"	"	Sand gravel	"	6,000
711	"	Sandy Hook Bay in Horseshoe	Lat 40 26 45 Long 73 59 50	20	"	"	Sand	"	2,600
712	"	Sandy Hook bay west of point of hook	Lat 40 28 35 Long 74 01 25	30	"	"	Sand	"	3,600
713	"	Lower bay-in main ship channel by buoy #8	Lat 40 28 45 Long 74 01 25	40.	"	"	Sand	"	3,200
714	"	Half way between buoy #8 and Romer light	Lat 40 29 50 Long 74 01 00	40	"	"	Sand	"	2,800
715	"	50 ft.inside Coney Is. channel near bell buoy	Lat 40 34 15 Long 73 59 50	20	"	"	Sand	"	2,800
716	"	Coney Is.channel by bell buoy off Sea Gate Inn	Lat 40 34 05 Long 73 59 50	30	Black	Sewage	Sand	"	1,000,000
717	"	On East Bank	Lat 40 32 35 Long 73 59 45	10	Brown	None	Sand	"	2,400
718	"	In Fourteen foot channel	Lat 40 31 50 Long 74 00 25	20	Black	Sewage	Mud	Polluted	1,800,000
719	"	On Romer Shoals	Lat 40 31 20 Long 74 00 35	15	Brown	None	Sand	Unpolluted	2,100
720	"	In Swash channel 700 ft. southwest of Romer light	Lat 40 30 40 Long 74 00 50	30	Black	Sewage	Mud	Polluted	1,200,000
721	"	In Swash channel 500 ft. northest of black and red buoy	Lat 40 31 20 Long 74 02 15	30	"	"	Mud	"	1,600,000
722	"	In Main ship channel west of buoy at junction of Swash and Main channel.	Lat 40 31 20 Long 74 02 30	40	"	"	Mud	"	2,000,000

Examination of Deposits from the Harbor Bottom, Lower Bay.

Examination No.	Date of collection	Location of Samples		Exact			Depth in water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
		Approximate		°	'	"						
723	July 21, 1909	500 feet west of West Bank Light	Lat	40	32	15	20	Brown	Marshy	Sand Clay	Doubtful	600,000
			Long	74	02	45						
724	"	Half way between West Bank light and Elm Tree Beacon	Lat	40	33	05	15	"	None	Sand	Unpolluted	6,000
			Long	73	04	10						
725	"	1000 ft. off Elm Tree Beacon.	Lat	40	33	45	10	"	"	"	"	4,800
			Long	74	06	30						

Ex. 98. p.65

Examination of Deposits from the Harbor Bottom — Atlantic Ocean

Examination No.	Date of Collection	Location of Samples — Approximate	Exact			Depth of Water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
726	July 21,09	Atlantic Ocean in so-called "Mud Gorge" about 10 miles east of Long Branch	Lat 40 19 15 Long 73 48 45			145	Green	Marshy	Silt	Unpolluted	6,400
727	"	Atlantic Ocean in so-called "Mud Gorge" 10 miles off Long Branch	Lat 40 19 15 Long 73 48 45			145	"	"	"	"	5,600
728	"	Atlantic Ocean about 12 miles due east of Long Branch, easterly edge of "Mud Gorge"	Lat 40 19 15 Long 73 47 15			150	"	"	"	"	4,800
729	"		Lat 40 19 15 Long 73 47 15			150	"	"	"	"	7,200
730	"	"Oil Spot" on false Sandy Hook 100 feet east of spar buoy 84	Lat 40 27 00 Long 73 58 25			20	Brown	None	Sand	"	2,800
731	"	"Oil Spot" on false Sandy Hook 1000 feet east of spar buoy 84	Lat 40 27 05 Long 73 58 25			20	"	"	"	"	1,600

Examination of Deposits from the Harbor Bottom. Hudson River.

Examination No.	Date of collection	Location of Samples — Approximate		Exact ° ' "	Depth of water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
732	Aug. 19, 1909	Half way across the Hudson on a line with Pier 1	Lat Long	40 42 23 74 01 35	50	Black	Sewage	Mud	Doubtful	1000,000
733	"	Half way across Hudson opposite Pier 17	Lat Long	40 43 00 74 01 25	40	-	-	Gravel	Unpolluted	-
734	"	50 ft. off end of Pier 17 Hudson River	Lat Long	40 42 56 74 01 01	40	Gray	Sewage	Mud	Polluted	1300,000
735	"	Hudson River, half way across from Pier 32	Lat Long	40 43 34 74 01 19	40	"	-	Clay	"	650,000
736	"	Hudson River, half way across from Pier 48	Lat Long	40 44 08 74 01 11	40	"	-	"	"	750,000
737	Sept. 7, 1909	Hudson River, 500 ft. off foot of W. 72 St.	Lat Long	40 46 54 73 59 25	35	Black	-	Mud	"	-
738	"	Hudson River, 500 ft. off foot of W. 110 St.	Lat Long	40 48 23 73 58 18	40	"	-	"	Unpolluted	-
739	"	Hudson River, 500 ft. off foot of 140 St.	Lat Long	40 49 31 73 57 27	40	Blue	-	Clay	"	-
740	"	Hudson River, 500 ft. off Washington Point	Lat Long	40 51 02 73 56 56	40	-	-	Gravel	"	-
741	"	Hudson River, 500 ft. off Inwood Bathing Beach	Lat Long	40 52 17 73 55 56	40	Gray	-	Mud	Polluted	-
742	"	Hudson River, 500 ft. off Spuyten Duyvil Creek	Lat Long	40 52 44 73 55 40	40	-	-	Gravel	Unpolluted	-
743	"	Hudson River, 500 ft. off Federal Refining Plant, Yonkers	Lat Long	40 55 45 73 54 23	40	Gray	-	Gravel Mud	"	-
744	"	Hudson River, 500 ft. off Power Plant northern limit of Yonkers	Lat Long	40 56 52 73 54 07	35	Brown	-	Sand	"	-

Examination of Deposits from the Harbor Bottom Passaic River and Newark Bay

Examination No.	Date of Collection	Location of Samples Approximate	Exact			Depth of Water feet	Color	Odor	Consistency	Opinion
745	Sept.8,09	Passaic River 200 ft.below P.R.R.passenger bridge, Newark	Lat	40	43 14	18	Black	Oily	Mud	Polluted
			Long	74	09 55					
746	"	Passaic River 100 ft.above P.R.R.freight bridge below Newark	Lat	40	44 09	18	"	-	"	"
			Long	74	09 45					
747	"	Passaic River 100 ft.below N.Y. and Newark R.R.bridge	Lat	40	43 21	18	Blue	-	Clay	Unpolluted
			Long	74	07 20					
748	"	Newark Bay 100 feet below Lehigh Valley Bridge	Lat	40	41 54	18	"	-	"	"
			Long	74	07 12					
749	"	Newark Bay 200 ft.west of red bell buoy off Centreville	Lat	40	40 18	18	"	-	"	Polluted
			Long	74	08 08					
750	"	Newark Bay 100 ft.below C.R.R. of N.J.bridge	Lat	40	39 14	18	-	-	Sand	Unpolluted
			Long	74	08 49					

Examination of Deposits from the Harbor Bottom. Kill van Kull.

Examination No.	Date of collection	Location of Samples: Approximate	Exact			Depth of water Feet	Color	Odor	Consistency	Opinion
v81	Sept. 8, 1909	Kill van Kull, West End 1000 ft. east of light house	Lat	40	38 35	38	-	-	Gravel	-
			Long	74	08 45					
782	"	Kill van Kull, Midstream opposite Sailors' Snug Harbor Station	Lat	40	38 50	40	-	-	Sand Gravel	Unpolluted
			Long	74	08 50					
783	"	Kill van Kull East end opposite end of Constable Hook, midstream	Lat	40	39 06	40	-	-	"	"
			Long	74	08 10					
784	Sept.11, 1909	Kill van Kull, midstream off Sailors Snug Harbor	Lat	40	39 20	40	-	-	Gravel	"
			Long	74	08 25					
785	"	Kill van Kull, midstream off Port Richmond	Lat	40	38 36	40	-	-	Sand	Polluted
			Long	74	07 52					
786	"	Kill van Kull west end 800 ft. South of Shooters Is.	Lat	40	39 20	35	-	-	Gravel Sand	Unpolluted
			Long	74	09 30					

Ex. 98. p.69

Examination of Deposits from the Harbor Bottom. Lower Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth of water Feet	Color	Odor	Consistency	Opinion
757	Sept. 13, 1909	Lower Bay, 200 ft. southeast of Ambrose Channel buoy 24	Lat 40 33 30 Long 74 01 25	35	Gray	-	Sand	Unpolluted
758	"	Lower Bay, 1500 ft. east of A.C. buoy 20	Lat 40 32 23 Long 74 00 45	25	Black	Sewage H_2S	Mud	Doubtful
759	"	Lower Bay, 500 ft. northeast of A.C. buoy 10	Lat 40 31 00 Long 73 58 45	20	Gray	-	Sand	Unpolluted
760	"	Lower Bay, about 1000 ft. north of A.C. buoy 4	Lat 40 30 20 Long 73 57 00	20	"	-	"	"
761	"	Lower Bay, 100 ft. northeast of A. C. buoy 4	Lat 40 30 10 Long 73 56 55	35	"	-	"	"
762	"	Lower Bay, 100 ft. south of A.C. buoy 3	Lat 40 29 55 Long 73 57 05	20	Brown	-	"	"
763	"	Lower Bay, 100 ft. north of buoy G6.	Lat 40 29 30 Long 73 57 20	30	"	-	"	Polluted
764	"	Lower Bay, Midway between G 6 and G 5	Lat 40 29 25 Long 73 57 20	35	Black	-	"	Unpolluted
765	"	Lower Bay, 200 ft. south of buoy G 5	Lat 40 29 10 Long 73 57 20	30	Brown	-	Gravel	"
766	"	Lower Bay, 100 ft. south of buoy C.B.1 off Sandy Hook	Lat 40 29 15 Long 73 58 15	30	"	-	Sand	"
767	"	Lower Bay 500 ft. S.W. of buoy C.B.3 off Sandy Hook	Lat 40 28 50 Long 73 59 10	35	"	-	"	"
768	"	Lower Bay, Main Ship's channel 1000 ft. northeast of buoy N 8	Lat 40 28 55 Long 74 01 20	35	Gray	-	"	"
769	"	Lower Bay, 500 ft. S.W. of buoy C.S. 1 South of Swash channel	Lat 40 29 35 Long 74 00 30	35	Brown	-	"	"

Examination of Deposits from the Harbor Bottom. Lower Bay.

Examination No.	Date of collection	Location of Samples — Approximate	Exact				Depth of water Feet	Color	Odor	Consistency	Opinion
				o	'	"					
770	Sept.14, 1909	Lower Bay,200 ft. east of West Bank light	Lat	40	32	20	35	Black	-	Mud Sand	Polluted
			Long	74	02	30					
771	"	Lower Bay between 2 buoys at junction of Swash and Main channels	Lat	40	31	25	30	"	-	"	"
			Long	74	02	20					
772	"	Lower Bay,300 ft. northeast of buoy C.S. 3	Lat	40	30	50	20	"	H_2S	Mud	"
			Long	74	01	45					
773	"	Lower Bay,500 ft. south of Romer light	Lat	40	30	45	30	Gray	-	Mud	Doubtful
			Long	74	00	45					
774	"	Lower Bay,500 ft. south of buoy N.S. 4	Lat	40	30	00	30	Brown	-	Sand	Unpolluted
			Long	73	59	45					
775	"	Lower Bay,500 ft. north of buoy C.S. 1	Lat	40	29	45	25	"	-	"	"
			Long	74	00	30					
776	"	Lower Bay,500 ft. northwest of buoy N.S.2	Lat	40	29	50	25	"	-	"	"
			Long	73	59	20					
777	"	Lower Bay,500 ft. southeast of black buoy S.9	Lat	40	30	45	20	Gray	-	"	"
			Long	73	58	45					
778	"	Lower Bay,500 ft. northwest of Red buoy S 10.	Lat	40	31	00	25	"	-	"	"
			Long	73	58	55					
779	"	Lower Bay, 1/3 distance between buoy A.C. 8 and Manhattan Beach	Lat	40	32	05	30	"	-	"	"
			Long	73	57	40					
780	"	Lower Bay, 2/3 distance between buoy A.C.8 and Manhattan Beach	Lat	40	33	05	22	Brown	-	"	"
			Long	73	57	25					

Examination of Deposits from the Harbor Bottom. Arthur Kill.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	°	'	"	Depth of water Feet	Color	Odor	Consistency	Opinion
781	Sept. 16, 1909	Rahway River ½ mile from mouth	Lat	40	35	55	8	Black	-	Mud	Unpolluted
			Long	74	12	45					
782	"	Arthur Kill, opposite mouth of Rahway River	Lat	40	35	35	10	"	Oily	"	Doubtful
			Long	74	12	15					
783	"	Arthur Kill, opposite Fresh Kills.	Lat	40	34	45	15	"	-	Sand	Unpolluted
			Long	74	12	35					
784	"	Arthur Kill, by buoy S 6 north of Rahway River	Lat	40	35	45	12	"	-	Mud	Unpolluted
			Long	74	12	05				Sand	
785	"	Arthur Kill, by buoy S 4 at east end of Kill	Lat	40	38	45	15	"	-	"	Polluted
			Long	74	10	45					
786	"	Kill van Kull between Shooters Is. and Mariners Harbor	Lat	40	28	35	35	"	-	Mud	Doubtful
			Long	74	09	30					

Examination of Deposits from the Harbor Bottom. Lower Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact ° ' "	Depth of water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
787	Sept. 20, 1909	Lower Bay, 800 ft. southwest West Bank light	Lat 40 32 10 Long 74 02 40	20	Brown	Marshy	Sand	Polluted	-
788	"	Lower Bay, about 1 mile from West Banks light in line with Port Monmouth	Lat 40 31 25 Long 74 03 00	20	Black	Sewage	Mud	"	-
789	"	Lower Bay, near white buoy 8 on same line	Lat 40 30 20 Long 74 03 15	20	Brown	None	Sand	Unpolluted	
790	"	Lower Bay, farther north on same line	Lat 40 29 35 Long 74 03 25	25	"	"	"	Doubtful	
791	"	Lower Bay, 1000 ft. west of buoy C.C. 1	Lat 40 28 35 Long 74 03 15	25	Black	Marshy	"	Polluted	530,000
792	"	Lower Bay, farther south on same line	Lat 40 27 40 Long 74 02 40	20	Brown	-	"	"	230,000
793	"	Lower Bay, about 1 mile off Atlantic Highlands	Lat 40 26 25 Long 74 03 15	20	Black	-	Sand Mud	"	320,000
794	"	Lower Bay, about ½ mile off Atlantic Highlands	Lat 40 25 50 Long 74 03 25	18	Brown	-	" "	"	240,000
795	"	Lower Bay, 2000 ft. west of buoy 3.1 W off Ft. Comfort	Lat 40 29 00 Long 74 07 50	12	"	-	Sand	Unpolluted	360,000
796	"	Lower Bay, nearer Great Kills	Lat 40 29 50 Long 74 07 40	25	Black	-	Mud	"	230,000
797	"	Lower Bay, 1½ miles south of Great Kills	Lat 40 30 35 Long 74 07 40	15	Brown	-	Sand	"	1,000,000
798	"	Lower Bay, 1 mile south of Great Kills	Lat 40 31 10 Long 74 07 45	10	"	-	"	"	150,000

Examination of Deposits from the Harbor Bottom. Raritan Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth of water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
799	Sept. 21, 1909	Raritan Bay, off Seguine Pt. 1000 ft. east of buoy S 3	Lat 40 30 30 Long 74 01 05	20	Black	-	Mud	Doubtful	-
800	"	Raritan Bay. By buoy S.3 in Seguine channel	Lat 40 30 30 Long 74 11 25	25	-	-	Gravel	-	-
801	"	Raritan Bay. 1000 ft. south east Princess Bay light	Lat 40 30 20 Long 74 12 35	20	Black	-	Mud	Doubtful	300,000
802	"	Raritan Bay. By red buoy S.6	Lat 40 29 48 Long 74 12 35	25	"	-	Mud	"	450,000
803	"	Raritan Bay, by red buoy S. 8	Lat 40 29 05 Long 74 14 20	25	"	-	"	"	380,000
804	"	Raritan Bay, 500 ft. north of Great Beds light	Lat 40 29 15 Long 74 15 15	16	-	-	Clinkers	-	

Examination of Deposits from the Harbor Bottom. Arthur Kill.

Examination No.	Date of collection	Location of Samples: Approximate	Exact			Depth of water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
			°	'	"						
805	Sept. 21,1909	Arthur Kill, 200 ft. west of buoy 9	Lat	40	30 10	20	Brown	-	Mud	Unpolluted	490,000
			Long	74	18 40						
806	"	Arthur Kill, 200 ft. west of buoy 8, at Tottenville, S.I.	Lat	40	30 58	20	-	-	Clinkers		
			Long	74	18 18						

Ex. 99. p.70

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of Collection	Location of Sample: Approximate	Depth of water Feet	Color Odor Consistency	Opinion	Bacteria per c.c.
807	Oct. 1, 1909	Hudson River, 150 ft. out from Pier 4	Lat. 40° 42' 46" N. Long. 74° 01' 07" W.	40	Black Sewage Odor	Polluted 300,000

Ex. 90, p.74

Examination of Deposits from the Harbor Bottom. Harlem River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact ° ' "	Depth of water Feet	Color	Odor	Consistency	Opinion	Bacteria per gram
808	Oct.11, 1909	Harlem River, Opposite E. 116 St. midstream	Lat 40 47 37 Long 73 55 47	20	Gray	Gas house	Mud	Polluted	150,000
809	"	Harlem River, Opposite E. 116 St. 50 feet off Manhattan shore	Lat 40 47 38 Long 73 55 50	20	"	Oily gas house	"	"	580,000
810	"	Harlem River, Opposite E. 110 St. Midstream	Lat 40 47 25 Long 73 56 03	20	Black	H_2S	"	"	300,000
811	"	Harlem River, Opposite E. 110 St. 50 ft. off Manhattan shore	Lat 40 47 26 Long 73 56 06	20	"	H_2S	"	"	-

Ex: 98. p.77

Examination of Deposits from the Harbor Bottom, East River.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact ° ' "	Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram.
812	Oct.1,	East River, 1000 feet off mouth of Newtown Creek	Lat 40 44 13 Long 73 57 57	30	Black	Oily gashouse	Sand	Polluted	1,300,000
813	"	East River, 1000 feet off mouth of Newtown Creek	Lat 40 44 13 Long 73 57 57	30	Black	Oily gashouse	Cinders	Doubtful	
814	"	East River, outer edge of Wallabout Bay	Lat 40 42 25 Long 73 58 30	30	Black	Oily H_2S	Mud	Polluted	1,100,000
815	"	East River, 200 feet outside Wallabout Canal	Lat 40 42 16 Long 73 58 13	15	Black	Oily H_2S	Mud	Polluted	450,000

Ex. 98. p.78

Examination of Deposits from the Harbor Bottom, Hudson River

Examination No.	Date of Collection	Location of Samples		Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram.
		Approximate	Exact						
816	Oct.2, 1909	Hudson River, 30 feet south of outer S.W. corner of Pier A	Lat 40 42 15 Long 74 01 08	40	Black	Sewage	Mud	Polluted	750,000

Ex. 98. p.79

Examination of Deposits from the Harbor Bottom, Harlem River.

Examination No.	Date of Collection	Location of Samples		Exact ° ' "	Depth of water (feet)	Color	Odor	Consistency	Opinion	Bacteria per gram
		Approximate								
817	Oct.2, 1909	Harlem River, opposite E. 103rd St. midstream	Lat	40 47 09	25	Black	H_2S	Mud	Polluted	650,000
			Long	73 56 15						
818	"	Harlem River, opposite E. 105th St. midstream	Lat	40 47 13	25	Black	H_2S	Mud	Polluted	
			Long	73 56 12						
819	"	Harlem River, opposite E. 108th St. midstream	Lat	40 47 21	25	Black	H_2S	Mud	Polluted	1,700,000
			Long	73 56 06						

Ex. 98. p.60

Examination of Deposits from the Harbor Bottom, Newtown Creek.

Examination No.	Date of Collection	Location of Samples		Exact			Depth of water (feet)	Color	Odor	Consistency	Opinion
		Approximate		°	'	"					
820	Oct.2 1909	Newtown Creek, 100 feet below first bridge	Lat Long	40 73	44 57	21 21	20	Black		Gravel	Polluted

Ex. 98. p.81

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of Collection	Location of Samples: Approximate	Exact ° ' "	Depth in feet: water	mud	Color	Odor	Consistency	Opinion	Bacteria per gram.
821	Oct.4, 1909	By buoy S. A. off Gowanus Bay	Lat 40 39 45 Long 74 01 20	30	0	Black	Oily H_2S	Mud	Polluted	700,000
822	"	" " "	Lat 40 39 45 Long 74 01 20	30	1	Black	H_2S	Sand	Unpolluted	500,000
823	"	" " "	Lat 40 39 45 Long 74 01 20	30	2	Black	H_2S	Mud and sand	Doubtful	600,000
824	"	" " "	Lat 40 39 45 Long 74 01 20	30	3	Grby	H_2S	Clay	Unpolluted	780,000
825	"	" " "	Lat 40 39 45 Long 74 01 20	30	4	Grey	H_2S	Clay	Doubtful	900,000
826	"	" " "	Lat 40 39 45 Long 74 01 20	30	5	Grey	H_2S	Clay	Unpolluted	2,800,000
827	"	" " "	Lat 40 39 45 Long 74 01 20	30	6	Grey	H_2S	Clay sand	Doubtful	2,000,000
828	"	" " "	Lat 40 39 45 Long 74 01 20	30	7	Grey		Clay sand	Doubtful	900,000
829	"	" " "	Lat 40 39 45 Long 74 01 20	30	8	Grey		Clay sand	Polluted	1,000,000
830	"	" " "	Lat 40 39 45 Long 74 01 20	30	9	Grey		Clay sand	Unpolluted	500,000
831	"	" " "	Lat 40 39 45 Long 74 01 20	30	10	Grey		Clay sand	Doubtful	600,000

ex. 99. v.88

Examination of Deposits from the Harbor Bottom, Gowanus Canal.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact ° ' "	Depth in Feet Water-Mud		Color	Odor	Consistency	Opinion	Bacteria per gram.
832	Oct. 4 1909	Gowanus Canal, at foot of Clinton St.	Lat 40 39 57 Long 74 00 25	20	0	Black	Gas	Mud	Polluted	3,000,000
833	"	" " " " "	" 40 39 57 " 74 00 25	20	1	Black	Gas	Mud	Polluted	1,700,000
834	"	" " " " "	" 40 39 57 " 74 00 25	20	2	Black	Gas	Mud	Polluted	1,900,000
835	"	" " " " "	" 40 39 57 " 74 00 25	20	3	Black	Gas	Mud	Polluted	600,000
836	"	" " " " "	" 40 39 57 " 74 00 25	20	4	Black	Gas	Mud	Polluted	310,000
837	"	" " " " "	" 40 39 57 " 74 00 25	20	5	Black	Gas	Mud	Polluted	450,000

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact ° ' "	Depth in feet Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
838	Oct.6, 1909	Upper Bay, 50 feet south of buoy N 14	Lat 40 40 33 Long 74 02 10	20	0	Black	H_2S	Mud sand	Polluted	500,000
839	"	" " " " "	Lat 40 40 33 Long 74 02 10	20	1	Black	H_2S	Mud sand	Polluted	330,000
840	"	" " " " "	Lat 40 40 33 Long 74 02 10	20	2	Black	H_2S	Mud sand	Polluted	200,000
841	"	" " " " "	Lat 40 40 33 Long 74 02 10	20	3	Gray	H_2S	Sand	Unpolluted	320,000
842	"	" " " " "	Lat 40 40 33 Long 74 02 10	20	4	Gray		Sand	Unpolluted	250,000
843	"	Upper Bay, in Red Hook channel, 30 feet off pier 46.	Lat 40 40 20 Long 74 01 10	30	0	Black	Gas house H_2S	Mud	Polluted	1,500,000
844	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	1	Black	H_2S	Mud	Polluted	410,000
845	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	2	Black	H_2S	Mud	Polluted	330,000
846	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	3	Black	H_2S	Mud	Polluted	440,000
847	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	4	Black	H_2S	Mud	Polluted	1,000,000
848	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	5	Black	H_2S	Mud	Polluted	2,000,000
849	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	6	Black	H_2S	Mud	Polluted	300,000
850	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	7	Black	H_2S	Mud	Polluted	500,000
851	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	8	Black	H_2S	Mud sand	Polluted	700,000
852	"	" " " " "	Lat 40 40 20 Long 74 01 10	30	9	Black	H_2S	Mud sand	Polluted	250,000

Examination of Deposits from the Harbor Bottom, Upper Bay (Continued)

Examination No.	Date of Collection.	Location of Samples: Approximate	Exact	Depth in Feet "Water-Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
853	Oct.7,1909	Upper Bay-30 ft.east of bell buoy #12 1/2	Lat 40 38 22 Long 74 03 13	25 0	Black	H_2S	Mud	Polluted	450,000
854	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 1	Black	"	"	"	1,200,000
855	"	Upper Bay-30 ft.east of Bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 2	Black	"	"	Unpolluted	200,000
856	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 3	Black	"	"	"	300,000
857	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 4	Black	"	"	"	400,000
858	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 5	Gray	"	Mud sand	"	600,000
859	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 6	Gray	"	Mud Sand	"	200,000
860	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 7	Gray	"	Mud sand	"	260,000
861	"	Upper Bay-30 ft.east of bell buoy # 12 1/2	Lat 40 38 22 Long 74 03 13	25 8	Gray	"	Mud sand	"	210,000
862	"	Upper Bay-20 ft.south of end of new ferry dock, Stapleton, S.I.	Lat 40 37 37 Long 74 04 09	26 0	Black	"	Mud	Polluted	400,000
863	"	" "	Lat 40 37 37 Long 74 04 09	26 3	Black	"	Mud	Doubtful	150,000
864	"	" "	Lat 40 37 37 Long 74 04 09	26 4	Black	"	"	"	250,000
865	"	" "	Lat 40 37 37 Long 74 04 09	26 5	Black	"	"	"	380,000
866	"	" "	Lat 40 37 37 Long 74 04 09	26 6	Gray	"	Clay sand	"	110,000
867	"	" "	Lat 40 37 37 Long 74 04 09	26 7	Gray	"	Clay sand	Unpolluted	800,000

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued).

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth in Feet — Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram.
868	Oct. 7 1909	Upper Bay, 20 ft. south of end of new ferry dock, Stapleton, S.I.	Lat 40 37 37 Long 74 04 09	26	8	Gray	H_2S	Clay sand	Unpolluted	200,000
869	"	" " "	Lat 40 37 37 Long 74 04 09	26	9	Gray	H_2S	Clay sand	Unpolluted	130,000
870	"	" " "	Lat 40 37 37 Long 74 04 09	26	10	Gray	H_2S	Clay sand	Unpolluted	210,000
871	Oct. 6 1909	Upper Bay, midway between Robbins Reed light and Owl Head	Lat 40 38 54 Long 74 03 06	32	0	Black	H_2S	Mud	Doubtful	300,000
872	"	" " " "	Lat 40 38 54 Long 74 03 06	32	1	Black	H_2S	Mud	Unpolluted	130,000
873	"	" " " "	Lat 40 38 54 Long 74 03 06	32	2	Gray	H_2S	Clay	Unpolluted	220,000
874	"	" " " "	Lat 40 38 54 Long 74 03 06	32	3	Gray	H_2S	Clay	Unpolluted	300,000
875	"	" " " "	Lat 40 38 54 Long 74 03 06	32	4	Gray	H_2S	Clay	Unpolluted	250,000
876	"	" " " "	Lat 40 38 54 Long 74 03 06	32	5	Gray	H_2S	Clay	Unpolluted	170,000
877	"	" " " "	Lat 40 38 54 Long 74 03 06	32	6	Gray	H_2S	Clay	Unpolluted	190,000
878	"	" " " "	Lat 40 38 54 Long 74 03 06	32	7	Gray	H_2S	Clay	Unpolluted	
879	"	" " " "	Lat 40 38 54 Long 74 03 06	32	8	Gray	H_2S	Clay	Unpolluted	
880	"	" " " "	Lat 40 38 54 Long 74 03 06	32	9	Gray	H_2S	Clay	Unpolluted	
881	"	" " " "	Lat 40 38 54 Long 74 03 06	32	10	Gray	H_2S	Clay	Unpolluted	

Examination of Deposits from the Harbor Bottom, Kill van Kull.

Examination No.	Date of Collection	Location of Samples	Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion
882	Oct. 8, 1909	Kill van Kull, 50 ft. off dock at ferry, Port Richmond, S.I. Exact Lat 40 38 30 Long 74 07 53	20	0	Black	H_2S	Mud	Polluted
883	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	1	Black	H_2S	Mud	Polluted
884	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	2	Black	H_2S	Mud	Polluted
885	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	3	Black	H_2S	Mud	Polluted
886	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	4	Black	H_2S	Mud	Polluted
887	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	5	Black	H_2S	Mud	Polluted
888	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	6	Black	H_2S	Mud	Polluted
889	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	7	Black	H_2S	Mud	Polluted
890	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	8	Black	H_2S	Mud	Polluted
891	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	9	Black	H_2S	Mud	Polluted
892	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	10	Black	H_2S	Mud	Polluted
893	"	" " " " " " Lat 40 38 30 Long 74 07 53	20	11	Black	H_2S	Mud	Polluted

Examination of Deposits from the Harbor Bottom, Upper Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram.
894	Oct.11, 1909	Upper Bay, 50 ft. east of red buoy off Ellis Is.	Lat 40 41 50 Long 74 02 07	35	0	Black	H_2S	Mud and sand	Polluted	800,000
895	"	Upper Bay, 50 ft. east of red buoy off Ellis Is.	Lat 40 41 50 Long 74 02 07	36	1	Black	H_2S	Mud	Polluted	700,000
896	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	1	Black	H_2S	Mud	Polluted	700,000
897	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	3	Black	H_2S	Mud	Polluted	3,000,000
898	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	4	Black	H_2S	Mud	Polluted	1,800,000
899	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	5	Black	H_2S	Mud	Unpolluted	3,000,000
900	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	6	Black	H_2S	Mud	Unpolluted	480,000
901	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	7	Black	H_2S	Mud	Unpolluted	550,000
902	"	" " " " "	Lat 40 41 50 Long 74 02 07	35	8	Black gray	H_2S	Mud clay		300,000
903	"	Upper Bay, 1/2 mile west of Robbins Reef	Lat 40 39 24 Long 74 04 14	15	0	Black	Oil	Mud	Polluted	3,000,000
904	"	" " " "	Lat 40 39 24 Long 74 04 14	15	1	Black	H_2S	Mud sand	Unpolluted	1,800,000
905	"	" " " "	Lat 40 39 24 Long 74 04 14	15	2	Brown	Marshy	Sand	Unpolluted	1,600,000
906	"	" " " "	Lat 40 39 24 Long 74 04 14	15	3	Brown	Marshy	Sand	Unpolluted	

Examination of Deposits from the Harbor Bottom, Kill van Kull.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact Lat	Exact Long	Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
907	Oct. 11 1909	Kill van Kull, opposite Livingston St., S. I.	40 38 44	74 06 40	36	0	Black	Sewage	Mud	Polluted	800,000
908	"	"	40 38 44	74 06 40	36	1	Black	Kerosene	Mud	Polluted	900,000
909	"	"	40 38 44	74 06 40	36	2	Black	Kerosene	Mud	Polluted	900,000
910	"	"	40 38 44	74 06 40	36	3	Black	Kerosene	Mud	Polluted	1,800,000
911	"	"	40 38 44	74 06 40	36	4	Black	Kerosene	Mud	Unpolluted	170,000
912	"	"	40 38 44	74 06 40	36	5	Gray	H_2S	Mud	Unpolluted	220,000
913	"	"	40 38 44	74 06 40	36	6	Gray	H_2S	Mud	Unpolluted	480,000
914	"	"	40 38 44	74 06 40	36	7	Gray	H_2S	Mud	Unpolluted	150,000
915	"	"	40 38 44	74 06 40	36	8	Gray	H_2S	Mud	Unpolluted	

REPORT OF STATE OF NEW YORK VS. STATE OF NEW JERSEY. 1912

Examination of Deposits from the Harbor Bottom, Arthur Kill.

Examination No.	Date of Collection	Location of Samples Approximate	Exact	Depth of water (Feet)	Color	Odor	Consistency	Opinion	Bacteria per gram.
916	Oct.14, 1909	Arthur Kill, 200 ft. east of drawbridge at Elizabethport	Lat 40 38 20 Long 74 11 36		Gray	Sewage	Clay	Doubtful	840,000

Rm. 98. p.90

PROPERTY OF STATE OF NEW YORK IN STATE OF NEW JERSEY.

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact o ' "	Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram.
917	Oct.14, 1909	Newark Bay, 50 feet off Singer Pier, Elizabethport	Lat 40 39 10 Long 74 10 11	12	0	Black	H_2S	Mud	Polluted	680,000
918	"	" " " "	Lat 40 39 10 Long 74 10 11	12	1	Black	H_2S	Mud	Polluted	170,000
919	"	" " " "	Lat 40 39 10 Long 74 10 11	12	2	Black	H_2S	Mud	Polluted	340,000
920	"	" " " "	Lat 40 39 10 Long 74 10 11	12	3	Black	H_2S	Mud	Polluted	140,000
921	"	" " " "	Lat 40 39 10 Long 74 10 11	12	4	Black	H_2S	Mud	Polluted	
922	"	" " " "	Lat 40 39 10 Long 74 10 11	12	5	Black	H_2S	Mud	Polluted	480,000
923	"	" " " "	Lat 40 39 10 Long 74 10 11	12	6	Black	H_2S	Mud	Polluted	160,000
924	"	" " " "	Lat 40 39 10 Long 74 10 11	12	7	Black	H_2S	Mud	Polluted	240,000
925	"	" " " "	Lat 40 39 10 Long 74 10 11	12	8	Black	H_2S	Mud	Polluted	140,000
926	"	" " " "	Lat 40 39 10 Long 74 10 11	12	9	Black	H_2S	Mud	Polluted	230,000
927	"	" " " "	Lat 40 39 10 Long 74 10 11	12	10	Black	H_2S	Mud	Polluted	300,000
928	"	" " " "	Lat 40 39 10 Long 74 10 11	12	11	Black	H_2S	Mud	Polluted	120,000
929	"	Newark Bay, midway between Shooters Is. and Corner Stake light	Lat 40 38 49 Long 74 10 11	18	0	Black	Oily H_2S	Mud	Polluted	

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth in Feet — Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram.
930	Oct.14, 1909	Newark Bay, midway between Shooters Is. and Corner Stake light	Lat 40 38 49 Long 74 10 11	18	1	Black	H_2S	Mud	Polluted	2,000,000
931	"	Newark Bay, midway between Shooters Is. and Corner Stake light	Lat 40 38 49 Long 74 10 11	18	2	Black	H_2S	Mud	Polluted	1,800,000
932	"	" " " "	Lat 40 38 49 Long 74 10 11	18	3	Black	H_2S	Mud	Polluted	3,000,000
933	"	" " " "	Lat 40 38 49 Long 74 10 11	18	4	Black	H_2S	Mud	Polluted	1,600,000
934	"	" " " "	Lat 40 38 49 Long 74 10 11	18	5	Black	H_2S	Mud	Polluted	1,700,000
935	"	" " " "	Lat 40 38 49 Long 74 10 11	18	6	Black	H_2S	Mud	Polluted	900,000
936	"	" " " "	Lat 40 38 49 Long 74 10 11	18	7	Black	H_2S	Mud	Polluted	2,100,000
937	Oct.15,	Newark Bay, 300 feet south of C.R.R. of N. J. bridge	Lat 40 39 13 Long 74 08 45	12	0	Black	Sewage	Mud	Polluted	880,000
938	"	" " "	Lat 40 39 13 Long 74 08 45	12	1	Black	H_2S	Mud	Polluted	1,100,000
939	"	" " "	Lat 40 39 13 Long 74 08 45	12	2	Black	H_2S	Mud	Polluted	1,400,000
940	"	" " "	Lat 40 39 13 Long 74 08 45	12	3	Gray	H_2S	Clay	Unpolluted	200,000
941	"	" " "	Lat 40 39 13 Long 74 08 45	12	4	Gray	H_2S	Clay	Unpolluted	700,000
942	Oct."	Newark Bay, midway between red bell buoy and Centreville shore	Lat 40 40 07 Long 74 07 58	8	0	Gray	Marshy	Clay	Doubtful	750,000
943	"	" " "	Lat 40 40 07 Long 74 07 53	8	1	Gray	Marshy	Clay	Unpolluted	300,000

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact ° ' "	Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion	Bacteria
944	Oct.15, 1909	Newark Bay, midway between red bell buoy and Centreville shore	Lat 40 40 07	8	2	Gray	Marshy	Clay	Doubtful	300,000
			Long 74 -7 53							
945	"	" " " "	Lat 40 40 07	8	3	Gray	Marshy	Clay	Unpolluted	470,000
			Long 74 07 53							
946	"	Newark Bay, 200 feet east of black buoy C 3	Lat 40 41 21	12	0	Black	H2S	Sand	Polluted	1,200,000
			Long 74 07 38							
947	"	" " " " " "	Lat 40 41 21	12	1	Black	Marshy	Sand mud	Polluted	900,000
			Long 74 07 38							
948	"	" " " " " "	Lat 40 41 21	12	2	Gray	Marshy	Clay	Unpolluted	750,000
			Long 74 07 38							
949	"	" " " " " "	Lat 40 41 21	12	3	Gray	Marshy	Clay	Unpolluted	800,000
			Long 74 07 38							
950	"	" " " " " "	Lat 40 41 21	12	4	Gray	Marshy	Clay	Unpolluted	480,000
			Long 74 07 38							
951	"	" " " " " "	Lat 40 41 21	12	5	Gray	Marshy	Clay	Unpolluted	800,000
			Long 74 07 38							
952	"	" " " " " "	Lat 40 41 21	12	6	Gray	Marshy	Clay	Unpolluted	
			Long 74 07 38							
953	"	" " " " " "	Lat 40 41 21	12	7	Gray	Marshy	Clay	Unpolluted	420,000
			Long 74 07 38							
954	"	" " " " " "	Lat 40 41 21	12	8	Gray	Marshy	Clay	Unpolluted	560,000
			Long 74 07 38							
955	"	" " " " " "	Lat 40 41 21	12	9	Gray	Marshy	Clay	Unpolluted	420,000
			Long 74 07 38							
956	"	" " " " " "	Lat 40 41 21	12	10	Gray	Marshy	Clay	Unpolluted	
			Long 74 07 38							
957	"	Newark Bay, 100 ft. west of red and black buoy N above L.V.R.R.bridge	Lat 40 42 25	16	0	Black	H2S	Mud	Polluted	
			Long 74 07 11							

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples	Exact o ' "	Depth in feet Water	Depth in feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
958	Oct.15, 1909	Newark Bay, 100 feet west of red and black buoy N	Lat 40 42 25 Long 74 07 11	16	1	Black	H_2S	Mud	Polluted	
959	"	" " " "	Lat 40 42 25 Long 74 07 11	16	2	Black	H_2S	Mud	Polluted	
960	"	" " " "	Lat 40 42 25 Long 74 07 11	16	3	Black	H_2S	Mud	Polluted	
961	"	" " " "	Lat 40 42 25 Long 74 07 11	16	4	Black	H_2S	Mud	Polluted	
962	"	" " " "	Lat 40 42 25 Long 74 07 11	16	5	Black	H_2S	Mud	Polluted	

Examination of Deposits from the Harbor Bottom. Kill van Kull.

Examination No.	Date of collection	Location of Samples: Approximate	Exact: Lat	°	'	"	Depth of Water feet	Mud	Color	Odor	Consistency	Opinion
963	Oct.16, 1909	Kill van Kull, Pier head line off Bodine Creek	Lat	40	38	20	12	0	Black	Sewage	Mud	Polluted
			Long	74	07	39						
964	"	Kill van Kull, Pier head line off Bodine Creek	Lat	40	38	28	12	1	"	H_2S	"	"
			Long	74	07	39						
965	"	" "	Lat	40	38	29	12	2	"	"	"	"
			Long	74	07	39						
966	"	" "	Lat	40	38	28	12	3	"	"	"	"
			Long	74	07	39						
967	"	" "	Lat	40	38	28	12	4	"	"	"	"
			Long	74	07	39						
968	"	" "	Lat	40	38	28	12	5	"	"	"	"
			Long	74	07	39						
969	"	" "	Lat	40	38	28	12	6	"	"	"	"
			Long	74	07	39						
970	"	" "	Lat	40	38	28	12	7	"	"	"	"
			Long	74	07	39						
971	"	" "	Lat	40	38	28	12	8	"	"	"	"
			Long	74	07	39						
972	"	" "	Lat	40	38	28	12	9	"	"	"	"
			Long	74	07	39						

Ex. 96. p.95

PEOPLE OF STATE OF NEW YORK VS STATE OF NEW JERSEY. 1383

Examination of Deposits from the Harbor Bottom. Upper Bay.

Examination No.	Date of collection	Location of Samples: Approximate		Exact	Depth of feet Water	Mud	Color	Odor	Consistency	Opinion
973	Oct.16, 1909	Upper Bay,400 feet south of Port Liberty coal dock		lat 40 42 10 long 74 02 13	10	0	Black	Sewage	Mud Clay	Polluted
974	"	"	"	lat 40 42 10 long 74 02 16	10	1	"	"	Mud	"
975	"	"	"	lat 40 42 10 long 74 02 18	10	3	"	"	"	"
976	"	"	"	lat 40 42 10 long 74 02 16	10	5	Grey	Marshy	Clay	"
977	"	"	"	lat 40 42 10 long 74 02 18	10	4	"	"	"	Doubtful
978	"	"	"	lat 40 42 10 long 74 02 20	10	8	"	"	"	"
979	"	"	"	lat 40 42 10 long 74 02 18	10	6	"	"	"	Unpolluted
980	"	"	"	lat 40 42 10 long 74 02 18	10	7	"	"	"	"
981	"	"	"	lat 40 42 10 long 74 02 18	10	8	"	"	"	"
982	"	"	"	lat 40 42 10 long 74 02 18	10	9	"	"	"	"

Ex. 98. p.96

Examination of Deposits from the Harbor Bottom. Hudson River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact	Depth in feet: Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
983	Oct.18, 1909	Hudson River, end of pier 10th St., Hoboken	Lat 40 44 54 Long 74 01 24	30	0	Black	Sewage H_2S	Mud	Polluted	1,800,000
984	"	" "	Lat 40 44 54 Long 74 01 24	30	1	"	"	"	"	1,600,000
985	"	" "	Lat 40 44 54 Long 74 01 24	30	2	"	"	"	"	2,000,000
986	"	" "	Lat 40 44 54 Long 74 01 24	30	3	"	"	"	"	1,800,000
987	"	" "	Lat 40 44 54 Long 74 01 24	30	4	"	"	"	"	2,000,000
988	"	" "	Lat 40 44 54 Long 74 01 24	30	5	"	"	"	"	2,400,000
989	"	" "	Lat 40 44 54 Long 74 01 24	30	6	"	"	"	"	2,000,000
990	"	" "	Lat 40 44 54 Long 74 01 24	30	7	"	"	"	"	1,800,000
991	"	" "	Lat 40 44 54 Long 74 01 24	30	8	"	"	"	"	1,000,000
992	"	" "	Lat 40 44 54 Long 74 01 24	30	9	"	"	"	"	1,800,000
993	"	" "	Lat 40 44 54 Long 74 01 24	30	10	"	"	"	"	1,600,000

Ex. 98. p.97

5000 3

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact			Depth in Feet Water	Depth in Feet Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
994	Oct.21, 1909	Newark Bay,100 feet south of C.R.R.of N.J. bridge	Lat	40 39 15		15	0	Black	H_2S	Mud Sand	Polluted	2,400,000
			Long	74 08 22								
995	"	" "	Lat	40 39 15		15	1	"	"	"	"	2,000,000
			Long	74 08 22								
996	"	Newark Bay,1000 feet south of C.R.R.of N.J. bridge	Lat	40 39 06		8	0	"	"	Sand Mud	"	1,800,000
			Long	74 08 86								
997	"	" "	Lat	40 39 06		8	1	"	"	"	"	1,200,000
			Long	74 08 86								
998	"	Newark Bay,400 feet south of C.R.R.of N.J.bridge, 2000 feet from Elizabeth-port shore	Lat	40 39 13		12	0	"	"	Mud	"	2,000,000
			Long	74 09 45								
999	"	" "	Lat	40 39 13		12	1	"	"	Mud	"	1,800,000
			Long	74 09 45								
1000	"	" "	Lat	40 39 13		12	2	"	"	Mud Clay	"	800,000
			Long	74 09 45								
1001	"	" "	Lat	40 39 13		12	3	Gray	"	Clay	Unpolluted	250,000
			Long	74 09 45								
1002	"	" "	Lat	40 39 13		12	4	"	None	"	"	150,000
			Long	74 09 45								
1003	"	" "	Lat	40 39 13		12	5	"	"	"	"	120,000
			Long	74 09 45								
1004	"	" "	Lat	40 39 13		12	6	"	"	Sand Clay	"	40,000
			Long	74 09 45								
1005	"	Newark Bay,400 feet south of C.R.R.of N.J.bridge, 1000 feet off Elizabeth-port shore	Lat	40 39 14		9	0	Black	H_2S	Mud	Polluted	1,200,000
			Long	74 09 58								
1006	"	" "	Lat	40 39 14		9	1	"	"	Mud Sand	Unpolluted	800,000
			Long	74 09 58								
1007	"	" "	Lat	40 39 14		9	2	Gray	"	Clay	"	400,000
			Long	74 09 58								

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of collection	Location of Samples: Approximate	Exact			Depth in Feet: Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
			°	'	"							
1008	Oct.21, 1909	Newark Bay, 400 feet south of C.R.R. of N.J. bridge, 1000 feet off Elizabethport shore	Lat	40	39 14	9	3	Gray	H_2S	Clay	Unpolluted	200,000
			Long	74	09 58							
1009	"	" " "	Lat	40	39 14	9	4	"	"	"	"	160,000
			Long	74	09 58							
1010	"	" " "	Lat	40	39 14	9	5	"	"	"	"	180,000
			Long	74	09 58							
1011	"	" " "	Lat	40	39 14	9	6	"	"	"	"	600,000
			Long	74	09 58							
1012	"	" " "	Lat	40	39 14	9	7	"	"	"	"	1,700,000
			Long	74	09 58							
1013	"	" " "	Lat	40	39 14	9	8	"	"	"	"	1,200,000
			Long	74	09 58							
1014	"	" " "	Lat	40	39 14	9	9	"	"	"	"	1,800,000
			Long	74	09 58							
1015	"	" " "	Lat	40	39 14	9	10	"	"	"	"	1,800,000
			Long	74	09 58							

Ex. 98. p.99

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact			Depth in Feet: Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1016	Oct. 22, 1909	Hudson River, North side Scandinavian line pier, Hoboken	Lat	40 45 17		30	0	Black	Coal tar	Mud	Polluted	9,000,000
			Long	74 01 22								
1017	"	" "	Lat	40 45 17		30	1	"	"	"	"	7,000,000
			Long	74 01 22								
1018	"	" "	Lat	40 45 17		30	2	"	"	"	"	6,000,000
			Long	74 01 22								
1019	"	" "	Lat	40 45 17		30	3	"	"	"	"	4,000,000
			Long	74 01 22								
1020	"	" "	Lat	40 45 17		30	4	"	"	"	"	2,000,000
			Long	74 01 22								
1021	"	" "	Lat	40 45 17		30	5	"	"	"	"	1,800,000
			Long	74 01 22								
1022	"	" "	Lat	40 45 17		30	6	"	"	"	"	4,000,000
			Long	74 01 22								
1023	"	" "	Lat	40 45 17		30	7	"	"	"	"	3,000,000
			Long	74 01 22								
1024	"	" "	Lat	40 45 17		30	8	Gray	"	Clay	Unpolluted	2,000,000
			Long	74 01 22								
1025	"	" "	Lat	40 45 17		30	9	"	"	"	"	1,000,000
			Long	74 01 22								
1026	"	" "	Lat	40 45 17		30	10	"	"	"	"	1,500,000
			Long	74 01 22								
1027	"	" "	Lat	40 45 17		30	11	"	"	"	"	1,500,000
			Long	74 01 22								

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Upper Bay. (Continued)

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth in feet Water-Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1028	Oct.23, 1909	Upper Bay, Red Hook channel pier head line off Red Hook stores	Lat 40 40 43 Long 74 01 13	30 0	Black	Sewage	Mud	Polluted	1,800,000
1029	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 1	"	"	"	"	2,800,100
1030	"	" " " " " "	Lat 40 40 4[illegible] Long 74 01 13	30 2	Grey	None	Clay	Un-"	750,000
1031	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 3	"	"	"	" "	500,000
1032	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 4	"	"	"	" "	450,000
1033	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 5	"	"	"	" "	250,000
1034	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 6	"	"	"	" "	400,000
1035	"	" " " " " "	Lat 40 40 43 Long 74 01 13	30 7	"	"	"	" "	200,000

Ex. 98. p.101

THIS PAGE BOUND VERTICAL IN BOOK

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of Collection	Location of Samples — Approximate	Exact	Depth in feet Water-Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1036	Oct. 18, 1909	Hudson River, 300 feet off Jersey shore below ferry slip at 22nd street	Lat 40 49 47 Long 73 59 17	10	0	Gray	H_2S	Clay	Polluted	1,200,000
1037	"	" " " "	Lat 40 49 47 Long 73 59 17	10	1	"	"	"	"	600,000
1038	"	" " " "	Lat 40 49 47 Long 73 59 17	10	2	"	"	"	"	750,000
1039	"	" " " "	Lat 40 49 47 Long 73 59 17	10	3	"	"	"	Un-	"	600,000
1040	"	" " " "	Lat 40 49 47 Long 73 59 17	10	4	"	"	"	"	"	900,000
1041	"	" " " "	Lat 40 49 47 Long 73 59 17	10	5	"	None	"	"	"	280,000
1042	"	" " " "	Lat 40 49 47 Long 73 59 17	10	6	"	"	"	"	"	250,000
1043	"	" " " "	Lat 40 49 47 Long 73 59 17	10	7	"	"	"	"	"	300,000
1044	"	" " " "	Lat 40 49 47 Long 73 59 17	10	8	"	"	"	"	"	230,000

Examination of Deposits from the Harbor Bottom, Newark Bay.

Examination No.	Date of Collection	Location of Samples: Approximate	Exact	Depth in feet: Water	Depth in feet: Mud	Color	Odor	Consistency	Opinion	Bacteria per cmm
1045	Nov.3, 1909	Newark Bay, 800 feet north of C.R.R. of N.J. bridge 2000 feet off the Elizabethport shore	Lat 40 39 23 Long 74 09 45	6	0	Black	H_2S	Mud	Polluted	2,000,000
1046	"	" " " " "	Lat 40 39 29 Long 74 09 43	6	1	"	"	"	"	1,800,000
1047	"	" " " " "	Lat 40 39 25 Long 74 09 43	6	2	"	"	"	"	1,800,000
1048	"	" " " " "	Lat 40 39 23 Long 74 09 43	6	3	Grey	"	Clay Clay	"	300,000
1049	"	" " " " "	Lat 40 39 25 Long 74 09 48	6	4	"	"	Sand	"	250,000
1050	"	Newark Bay, 800 feet north of C.R.R. of N.J. bridge 1000 feet off the Elizabethport shore	Lat 40 39 22 Long 74 09 53	6	0	Black	"	Mud	"	4,000,000
1051	"	" " " " "	Lat 40 39 28 Long 74 09 59	6	1	"	"	"	"	3,000,000
1052	"	" " " " "	Lat 40 39 22 Long 74 09 59	6	2	Grey	"	Clay	Doubtful	1,800,000
1053	"	" " " " "	Lat 40 39 22 Long 74 09 59	6	3	"	"	"	Unpolluted	650,000
1054	"	" " " " "	Lat 40 39 22 Long 74 09 59	6	4	"	None	"	"	400,000
1055	"	" " " " "	Lat 40 39 28 Long 74 09 59	6	3	"	"	sand clay	"	800,000
1056	"	" " " " "	Lat 40 39 32 Long 74 09 59	6	6	Blue & Grey	"	sand clay	"	250,000
1057	"	" " " " "	Lat 40 39 21 Long 74 09 50	6	7	"	"	"	"	120,000

Ex. 90. p.108

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom Newark Bay

Examination No.	Date of Collection	Location of Samples: Approximate	Exact	Depth in feet "Water-Mud		Color	Odor	Consistency	Opinion	Bacteria per gram
1058	Nov.3,1909	Newark Bay 1000 fr. north of C.R.R.of N.J.bridge 1000 ft. off Centreville	Lat 40 39 27 Long 74 08 20	6	0	Black	Sewage	Sand	Polluted	3,000,000
1059	"	" "	Lat 40 39 27 Long 74 08 20	6	1	Gray	None	Clay & sand	"	250,000
1060	"	" "	Lat 40 39 27 Long 74 08 20	6	2	"	"	Clay & sand	Unpolluted	50,000
1061	"	" "	Lat 40 39 27 Long 74 08 20	6	3	"	"	Clay & sand	"	125,000
1062	"	" "	Lat 40 39 27 Long 74 08 20	6	4	"	"	Clay & sand	"	60,000
1063	"	" "	Lat 40 39 27 Long 74 08 20	6	5	"	"	Clay	"	50,000
1064	"	" "	Lat 40 39 27 Long 74 08 20	6	6	"	"	"	"	40,000
1065	"	" "	Lat 40 39 27 Long 74 08 20	6	7	"	"	"	"	20,000
1066	"	Newark Bay 1/2 mi. southeast of red buoy #4, 2000 ft. south of L.V.R.R. trestle	Lat 40 41 25 Long 74 06 52	8	0	"	H_2S	"	Polluted	2,000,000
1067	"	" "	Lat 40 41 25 Long 74 06 52	8	1	"	"	"	Doubtful	1,000,000
1068	"	" "	Lat 40 41 25 Long 74 06 52	8	2	"	"	"	Unpolluted	350,000
1069	"	" "	Lat 40 41 25 Long 74 06 52	8	3	"	"	"	"	250,000
1070	"	" "	Lat 40 41 25 Long 74 06 52	8	4	"	"	"	"	350,000

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Newark Bay. (Continued)

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth in feet — Water	Depth in feet — Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1071	Nov. 3, 1909	Newark Bay, ½ mile southeast of red buoy No. 4 2000 feet south of L.V. R.R. trestle	Lat 40 41 25 Long 74 06 52	8	5	Gray	H_2S	Clay	Unpolluted	80,000
1072	"	" " " " "	Lat 40 41 25 Long 74 06 52	8	6	"	"	"	"	60,000

Ex. 98. p.105

THIS PAGE BOUND VERTICAL IN BOOK

THIS PAGE BOUND VERTICAL IN BOOK

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples — Approximate	Exact	Depth Water	Depth Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1073	Nov. 4, 1909	Hudson River, opposite Ft. Washington Pt., 500 feet off the New Jersey shore	Lat 40 51 06 Long 74 57 32	12	0	Black	Sewage	Mud	Polluted	1,800,000
1074	"	" "	Lat 40 51 06 Long 73 57 32	12	1	Gray	H_2S	Clay	Unpolluted	1,000,000
1075	"	" "	Lat 40 51 06 Long 73 57 32	12	2	"	"	"	"	850,000
1076	"	" "	Lat 40 51 06 Long 73 57 32	12	3	"	"	"	"	700,000
1077	"	" "	Lat 40 51 06 Long 73 57 32	12	4	"	"	"	"	250,000
1078	"	" "	Lat 40 51 06 Long 73 57 32	12	5	"	"	"	"	100,000
1079	"	" "	Lat 40 51 06 Long 73 57 32	12	6	"	"	"	"	120,000
1080	"	" "	Lat 40 51 06 Long 73 57 32	12	7	"	"	"	"	250,000
1081	"	" "	Lat 40 51 06 Long 73 57 32	12	8	"	None	"	"	100,000
1082	"	" "	Lat 40 51 06 Long 73 57 32	12	9	"	"	"	"	12,000
1083	"	" "	Lat 40 51 06 Long 73 57 32	12	10	"	"	"	"	16,000
1084	Nov. 6, 1909	Hudson River, opposite W. 157th St., Manhattan, 500 feet off the New Jersey shore	Lat 40 50 31 Long 73 57 54	16	0	Black	Sewage	Mud	Polluted	1,800,000
1085	"	" "	Lat 40 50 31 Long 73 57 54	16	1	"	H_2S	Mud & Clay	"	1,200,000
1086	"	" "	Lat 40 50 31 Long 73 57 54	16	2	Gray	"	Clay	"	500,000
1087	"	" "	Lat 40 50 31 Long 73 57 54	16	3	"	"	"	"	500,000

Examination of Deposits from the Harbor Bottom, Hudson River.

Examination No.	Date of collection	Location of Samples: Approximate	Exact ° ' "	Depth in Feet: Water	Mud	Color	Odor	Consistency	Opinion	Bacteria per gram
1088	Nov.6, 1909	Hudson River, opposite W.157th St., Manhattan, 500 feet off the New Jersey shore	Lat 40 50 31 Long 73 57 54	16	4	Gray	H_2S	Clay	Polluted	250,000
1089	"	" "	Lat 40 50 31 Long 73 57 54	16	5	"	"	"	Unpolluted	400,000
1090	"	" "	Lat 40 50 31 Long 73 57 54	16	6	"	None	"	"	120,000
1091	"	" "	Lat 40 50 31 Long 73 57 54	16	7	"	"	"	"	50,000
1092	"	Hudson River, opposite W.59th St., Manhattan, 500 feet off the New Jersey shore	Lat 40 46 40 Long 74 00 20	35	0	Black	H_2S	Mud	Polluted	2,400,000
1093	"	" "	Lat 40 46 40 Long 74 00 20	35	1	"	"	"	"	2,000,000
1094	"	Hudson River, opposite W.59th St., Manhattan, 500 feet off the New Jersey shore	Lat 40 46 40 Long 74 00 20	35	2	"	"	"	"	1,800,000
1095	"	" "	Lat 40 46 40 Long 74 00 20	35	3	Gray	"	Clay	"	800,000
1096	"	" "	Lat 40 46 40 Long 74 00 20	35	4	"	"	"	"	600,000
1097	"	" "	Lat 40 46 40 Long 74 00 20	35	5	"	None	"	Unpolluted	400,000
1098	"	" "	Lat 40 46 40 Long 74 00 20	35	6	"	"	"	"	60,000
1099	"	" "	Lat 40 46 40 Long 74 00 20	35	7	"	"	"	"	40,000
1100	"	" "	Lat 40 46 40 Long 74 00 20	35	8	"	"	"	"	20,000

Ex. 98. p.107

THIS PAGE BOUND VERTICAL IN BOOK

PEOPLE OF THE STATE OF NEW YORK v. STATE OF NEW JERSEY AND PASSAIC VALLEY SEWERAGE COMMISSIONERS.

IN EQUITY.

No. 2, Original. Argued November 8, 11, 12, 1918; restored to docket for further argument March 10, 1919; reargued January 25, 1921.—Decided May 2, 1921.

New York brought this suit against New Jersey and the Passaic Valley Sewerage Commissioners, to enjoin the execution of a project to convey the sewage of the Passaic Valley through a sewer system and to discharge it into a part of New York Harbor, known as the Upper New York Bay, the plaintiff alleging that the sewage would be carried by the currents and tides into the Hudson and East Rivers and be deposited on the bottom and shores of the Bay and upon and adjacent to the wharves and docks of New York City, and would so pollute the water as to render it a public nuisance, offensive and injurious to persons living near it or using it for bathing or for purposes of commerce, damaging to vessels using the waters, and so poisonous to fish and oysters in it as to render them unfit for food. The United States intervening opposed the plan as threatening, unnecessarily, obstruction of navigable channels, injury to the health of persons navigating the waters and of officials and employees at a navy yard, and damage to government property bordering on the Bay; but withdrew, without prejudice, upon the filing of a stipulation executed by its Attorney General, and by the defendant sewer commissioners acting under authority of an act of the New Jersey legislature, agreeing upon a modification of the method proposed for purifying and dispersing the sewage, specifying the results that must be secured thereby or through requisite additional lawful arrangements, allowing the Government full opportunity to inspect the workings of the sewer system and providing that compliance with the stipulation should be made a condition of any permit issued by the Government for construction, maintenance or operation. The case having proceeded to final hearing between the original parties,—

Held: (1) That the right of New York to maintain such a suit on behalf of her citizens was clear, without regard to the precise lo-

cation of the boundary between the two States or to New York's claim of jurisdiction over the waters of New York Bay. P. 301.

(2) That the defendant Sewerage Commissioners constituted a statutory, corporate agency of New Jersey, whose acts and intentions in the premises must be treated as those of the State. P. 302.

(3) That, if the conditions of the stipulation were realized and maintained, there could be no occasion for the injunction prayed for. P. 305.

(4) That the stipulation was binding on New Jersey and the United States. P. 307.

(5) That the evidence must be considered subject to the principle that, before this court will exercise its extraordinary power to control the conduct of one State at the suit of another, the threatened invasion of rights must be of serious magnitude and established by clear and convincing evidence. P. 309.

(6) That the evidence failed to prove that the proposed addition of sewage would cause increased damage to hulls of vessels or danger of air-borne disease to persons navigating or dwelling along the water, or (if treated as proposed in the stipulation) damage to persons bathing, or fish or oysters subsisting, in the water, additional to that attributable to existing discharge of sewage from New York City and its environs. P. 309.

(7) That, as to the question remaining, the evidence failed to show with the requisite certainty, that, even if treated only as specifically prescribed in the stipulation, the additional sewage would create a public nuisance by causing offensive odors, or unsightly deposits on the surface, or seriously add to the existing pollution; and that, therefore, and in view of improved methods of sewage treatment disclosed by the testimony and of the right of the Government to stop the operation of the sewer if it caused pollution of the Bay, the injunction must be refused. P. 310.

The court suggests that the problem involved in this case is one more likely to be wisely solved by cooperative study and by conference and mutual concession on the part of the States interested than by proceedings in any court. P. 313.

Bill dismissed without prejudice.

THIS original case was first argued at the October Term of 1918, but, owing in part to the time that had then elapsed since the closing of the evidence, the court found it necessary to direct the taking of additional testimony on certain specified points. See 249 U. S. 202. The

facts are reviewed in the opinion. No attempt is made to reproduce the arguments which were mainly concerned with the matters of fact involved.

Mr. Charles E. Hughes, with whom *Mr. Charles D. Newton*, Attorney General of the State of New York, *Mr. William J. O'Sullivan*, *Mr. Russell Lord Tarbox* and *Mr. Allen S. Hubbard* were on the brief, for complainant.[1]

Mr. Adrian Riker and *Mr. George W. Wickersham*, with whom *Mr. Thomas F. McCran*, Attorney General of the State of New Jersey, and *Mr. Robert H. McCarter* were on the brief, for defendants.[1]

Mr. Justice Clarke delivered the opinion of the court.

The People of the State of New York, in their bill filed in this suit, pray that the defendants, the State of New Jersey and the Passaic Valley Sewerage Commissioners, be permanently enjoined from discharging, as it is averred they intend to discharge, a large volume of sewage into that part of New York Harbor known as the Upper Bay, for the reason, as it is alleged, that such pollution of the waters of the harbor will be caused thereby as to amount to a public nuisance, which will result in grave injury to the health, to the property, and to the commercial welfare, of the people of the State and City of New York.

The Passaic River rises in the northeasterly part of

[1] At the first hearing, the case was argued by *Mr. Charles E. Hughes* on behalf of the complainant. *Mr. Merton E. Lewis*, Attorney General of the State of New York, and *Mr. William J. O'Sullivan* were on the brief. *Mr. Adrian Riker* and *Mr. Robert H. McCarter* argued on behalf of the defendants. *Mr. John W. Wescott*, Attorney General of the State of New Jersey, was on the brief.

New Jersey and empties into Newark Bay. High land separates its watershed from direct drainage into the Hudson River or New York Bay, and on the lower twenty-five miles of it there are located the cities of Paterson, Passaic, and Newark, and also a number of such large towns that the population upon and near to the river is treated throughout the record as approximately 700,000 in 1911, when it was thought the sewer would be completed, and as likely to be about 1,650,000 in 1940, to which year it was designed to furnish adequate sewerage capacity. These cities and towns, from their earliest settlement, had all drained their sewage into the river. The ebbing and flowing of the tide almost to Paterson delayed the escaping of this sewage from the river and resulted in the water becoming greatly polluted. This polluted water was emptied directly into Newark Bay, but, ultimately, 84% of it, modified, no doubt, by nature's agencies, but still polluted, found its way through the natural channel of Kill van Kull, into Upper New York Bay.

This drainage of sewage into the Passaic River resulted in the stream becoming such a menace to the health and property of the adjacent communities that, in 1896, a commission was appointed by the Governor of New Jersey, under the provisions of an act of the legislature, to study the problem presented, for the purpose of devising some system of sewage disposal which would afford relief. After this commission had reported, a second commission of investigation was provided for by act of the legislature in 1897, and its report was followed by a third similar commission in 1898.

The reports of these various commissions led, in 1902, to an act of the New Jersey legislature creating the Passaic Valley Sewerage District, with boundaries embracing substantially the entire watershed of the Passaic River, and to another act, in 1907, prohibiting the dis-

charge of sewage into the river after a date named, and directing the defendant Passaic Valley Sewerage Commissioners to prepare plans and specifications for a trunk sewer to dispose of the sewage and authorizing municipalities to contract with them for the service which they might require.

Under authority of this act, the defendant Sewerage Commissioners, in April, 1908, adopted a plan for sewage disposal, which provided for a main intercepting sewer, extending from the City of Paterson, along the right bank of the Passaic River, to a point in the City of Newark, and thence by a tunnel under the waters of Newark Bay and the cities of Bayonne and Jersey City to a point in Upper New York Bay about 500 feet north of Robbins Reef Light, where it was proposed to discharge the sewage at a depth of 40 feet of water below mean low tide. The estimated cost of the proposed sewer was $12,250,000.

It was provided in the act authorizing the construction of the sewer that, before any work should be undertaken or obligations incurred, a further investigation should be made by the Commissioners as to whether the discharge of the sewage into New York Bay would be likely to pollute its waters to such an extent as to cause a nuisance to persons or property within the State of New York, and that the result of such investigation, with the reasons for it, should be presented to the Governor of the State.

Such an investigation was made and upon report of the Commissioners the Governor concluded that the discharge of the sewage as proposed would not pollute the waters of New York Bay so as to cause a nuisance to either persons or property within the State of New York, and the Attorney General of the State also advised the Governor that in his opinion the State of New York could not have any valid legal objection to the use of the sewer as proposed.

There can be no doubt that the various commissioners

who investigated this subject were men of the highest character and intelligence and that they studied it with the aid of the best obtainable sanitary engineers, chemists and bacteriologists, for the purpose of arriving at a solution which would protect and preserve the interests of all of the great communities involved. It is equally beyond doubt that the Governor and other officials of New Jersey, with full appreciation of the magnitude and seriousness of the undertaking, proceeded with great caution and with a settled purpose to fully respect the rights of the people of the State of New York.

Learning of the plans of the State of New Jersey, thus detailed, the legislature of New York passed an act providing for a commission to investigate the probable effect upon the waters of New York Bay of the proposed Passaic Valley sewer, with power to coöperate with the authorities of New Jersey with a view to arriving at some mutually satisfactory solution of the problem. The record shows that various conferences were held between the New York Commission thus created and the Passaic Valley Sewerage Commissioners, but for some reason, which does not clearly appear, no mutually satisfactory course of action was arrived at, with the result that, in October, 1908, this suit for an injunction was commenced.

For the purpose of showing its right to maintain the suit, the bill thus filed sets out, with much detail, an agreement between the States of New York and New Jersey, approved by Congress in 1834, establishing the boundary line between the two States and giving to New York, to the extent therein written, exclusive jurisdiction over the waters of the Bay of New York.

But we need not inquire curiously as to the rights of the State of New York derived from this compact, for, wholly aside from it, and regardless of the precise location of the boundary line, the right of the State to maintain such a suit as is stated in the bill is very clear. The health,

comfort and prosperity of the people of the State and the value of their property being gravely menaced, as it is averred that they are by the proposed action of the defendants, the State is the proper party to represent and defend such rights by resort to the remedy of an original suit in this court under the provisions of the Constitution of the United States. *Missouri* v. *Illinois*, 180 U. S. 208, 241, 243; *Georgia* v. *Tennessee Copper Co.*, 206 U. S. 230.

Also, for the purpose of showing the responsibility of the State of New Jersey for the proposed action of the defendant, the Passaic Valley Sewerage Commissioners, the bill sets out, with much detail, the acts of the legislature of that State authorizing and directing such action on their part.

Of this it is sufficient to say that the averments of the bill, quite undenied, show that the defendant sewerage commissioners constitute such a statutory, corporate agency of the State that their action, actual or intended, must be treated as that of the State itself, and we shall so regard it. 180 U. S. 208, *supra.*

The remaining essential allegations of the bill are that the defendants are about to construct the sewer we have described and to discharge the sewage thereby collected into the Upper New York Bay, through a single opening 12 feet in diameter, at a point about half a mile north of Robbins Reef Light; that there would be about 120 millions of gallons of such sewage discharged into the Bay every 24 hours in 1911, and in excess of 357 millions of gallons by 1940; that such sewage would be carried by the currents and tides into the Hudson and East Rivers and would be deposited on the bottom and shores of the Bay and upon and adjacent to the wharves and docks of New York City, thereby so polluting the water as to render it: a public nuisance offensive and injurious to persons living near it or using it for bathing or for purposes of commerce, damaging to vessels using the waters, and

so poisonous to the fish and oysters subsisting within it as to render them unfit for food. To prevent the public nuisance, which it is averred would thus be created, a permanent injunction was prayed for.

The essential denials and allegations of the answer are as follows:

Admitting their intention to construct the sewer substantially as described, it is averred: that New Jersey has a shore line of 25 miles on New York Bay and on the Hudson River, and that large cities and towns of that State border upon the Bay, so that it has as important an interest as New York has in maintaining the waters free from pollution; that the sewer project objected to was authorized only after it had been recommended and approved by sanitary engineers of highest professional standing and experience and upon their assurance, after careful study of the tidal flow and currents of the Bay, that appreciable pollution would not be caused thereby; that the Passaic River empties into Newark Bay and its water, charged, under existing conditions, with the sewage collected from the same communities intended to be served by the projected sewer, in large part reaches New York Bay in the vicinity of Robbins Reef Light, by natural channels, without causing substantial injury to the water; and that the City of New York has long been discharging into the Bay at or near to the shore lines thereof, daily, more than seven times as great a volume of sewage (entirely untreated) as the daily discharge of the proposed sewer would be for many years to come. The answer concludes with further denials that the waters of the Bay would be corrupted or their usefulness impaired by the use of the proposed intercepting sewer.

After the defendants had answered, the Government of the United States, by leave of court, filed a Petition of Intervention. The warrant assigned for this intervention was, the power and duty of the Government with respect

to navigation and interstate commerce, and the inherent power which it has to act for the protection of the health of government officials and employees at the Brooklyn navy yard, and its duty to protect from damage the Government property bordering upon New York Bay.

The projected sewer was described in this Petition of Intervention, substantially as in the original bill, but it was averred that the plans for the removal of solids from the sewage were so indefinite and inadequate that the use of the sewer would result in the obstruction of navigation by the filling up and shoaling of the channels of the Bay, and that the proposed purification of the sewage was so insufficient that the waters would be rendered unsightly and unhealthful to persons using them for commerce or dwelling upon the adjacent shores. It was averred that there were other, better and more advanced methods of sewage disposal than those proposed, and that the threatened injury to commerce and navigation, to the public health and to the property of the United States was not necessary. For these reasons the Government joined in the prayer for relief.

The coming of the Government into the case was followed by conferences between its officials and the Sewerage Commissioners, with the result that a method of treatment of the sewage was decided upon much more thorough, comprehensive and definite in character than had been adopted before and the manner of dispersion of it at the outlet was so changed as to secure a much greater diffusion, at a great depth, in the adjacent waters.

These changes were ultimately embodied in a stipulation between the United States, acting through its Attorney General, and the Passaic Valley Sewerage Commissioners, acting under authority of a special act of the New Jersey legislature. It was agreed that upon the filing of this stipulation, properly executed, with the

Clerk of this Court, the Petition of Intervention of the Government should be dismissed, without prejudice—which was done on May 16, 1910.

The stipulation provides, with much detail, that at or near to a pumping station to be located in the Newark Meadows, near Newark Bay, the material coming from the trunk sewer shall first pass through coarse screens to remove floating matter; then through a grit basin or basins, to remove heavy matter, as far as practicable; then through self-cleaning mechanical screens, with openings of not over four-tenths of an inch; and then through sedimentation basins, equipped with "scum boards," at a prescribed velocity of flow. It is provided that the effluent thus screened and settled shall flow into a pumping well, whence it is to be pumped under pressure to a point near Robins Reef Light, where it is to be discharged at a depth of not less than forty feet beneath the surface of the water at mean low tide, through 150 outlets, distributed over an area of three and one-half acres, and so arranged as to drive the material horizontally across the tidal currents.

The terms of this stipulation were adopted by the Government under the advice of Army engineers of high rank and by the Sewerage Commissioners on the advice of distinguished sanitary engineers and it must be accepted as established by the testimony taken in 1919 that at that time screening and sedimentation and thorough dispersion in water through deeply submerged multiple outlets was regarded by the most competent authorities as the most approved method of disposing of sewage in large volume.

But, not satisfied with providing what was thought sufficient treatment to render the sewage innocuous, there was incorporated into the stipulation an agreement on the part of the Sewerage Commissioners that in the actual operation of the sewer at all times the following

results should be secured, either through compliance with the requirements of the stipulation for treatment of the sewage, "or through requisite lawful additional arrangements," viz: (1) There will be absence in the New York Bay of visible suspended particles coming from this sewage; (2) there will be absence of deposits caused by it objectionable to the Secretary of War of the United States; (3) there will be absence of odors due to the putrefaction of organic matter contained in the sewage; (4) there will be absence on the surface of the Bay of any grease or color due to the sewage; (5) there will be no injury to the public health due to the discharge of the sewage, and no public or private nuisance will be created thereby; (6) no injurious effect shall result to the property of the United States situated upon the Bay; (7) there shall not be a reduction in the dissolved oxygen content of the waters, due to this sewage, sufficient to interfere with major fish life. It is agreed that the Government shall have unrestricted opportunity to inspect the workings of the sewer system, by designated officials, and that full compliance at all times with the provisions of the stipulation referred to shall be made an express condition of any permit issued by the Government for the construction, maintenance or operation of the projected sewer system.

It is obvious that, if the conditions of this stipulation are realized and maintained, there will be no occasion or ground for such an injunction as was prayed for.

It is argued, however, and expert witnesses have testified, that the provisions therein stipulated for screening and sedimentation and final dispersion of the sewage in the water, are not sufficient to produce the results which the Sewerage Commissioners agree with the Government to produce and maintain, and that if such results as are feared by the witnesses are produced it would be impossible to determine whether they were caused by this

particular sewage or by that coming from other sources and that therefore the agreement would, in practice, be nugatory. But equally well informed and credible witnesses testified that the proposed treatment would produce the stipulated results and that the source of such pollution, if any should be caused by the Passaic sewage, could readily be traced to its origin, and we think the probabilities greatly in favor of this conclusion, having regard to the opportunity secured to the Government for inspection and observation of the treatment plant and for determining the quality and content of effluent before it is discharged into the Bay and the effect which it may have on the water in the immediate vicinity of the outlet.

It is also argued that this stipulation is not binding upon the State of New Jersey because executed only by the Sewerage Commissioners, and that it is invalid for want of power in the Attorney General to so stipulate on behalf of the United States.

But since by act of its legislature the State of New Jersey specifically authorized the Sewerage Commissioners to execute the stipulation and by its special counsel entered of record its approval of, and consent to, it, we must and do regard it as the valid obligation of the State as certainly as of the Commissioners.

As to the United States: The intervention of the Government was allowed upon allegations that the inadequate treatment of the sewage proposed would result in injury to navigation and commerce: by causing deposits of solid matter, to the extent of thousands of tons annually, which would fill up and shallow the channels of the Bay; by rendering the Port of New York less serviceable and attractive to commerce and offensive and unwholesome to persons using and living near it; and by causing injury to the hulls of vessels by the character of the effluent to be discharged. It was also averred that

practically irreparable damage would be caused to extensive properties owned by the Government adjacent to the Bay.

Having regard to the large powers of the Government over navigation and commerce, its right to protect adjacent public property and its officers and employees from damage and disease, and to the duty and authority of the Attorney General to control and conduct litigation to which the Government may be a party (Rev. Stats., §§ 359, 367), we cannot doubt that the intervention of the Government was proper in this case and that it was within the authority of the Attorney General to agree that the United States should retire from the case upon the terms stated in the stipulation, which were plainly approved by the Secretary of War, who afterwards embodied them in the construction permit issued to the Sewerage Commissioners.

Although this stipulation was filed and the Government withdrew from the case on May 16, 1910, the remaining parties went forward and took a great volume of testimony, the taking of which was concluded in June, 1913. Five years passed before the case was brought on for argument at the October Term, 1918, and upon examination this court, having regard to the long time which had elapsed since the taking of testimony was closed and to the rapid advance in sanitary science then in progress, suggested in the record, directed that additional testimony should be taken in order that the court might be advised: (1) As to any practicable modification of the proposed sewer system which might improve it and reduce any polluting effect upon the water which might be caused by the effluent to be discharged; (2) as to any practicable plan or arrangement for sewage disposal which would lessen the polluting effect derived from the New York City sewage; (3) and as to the present degree of pollution of the waters of New York Harbor

and the change in this respect since the taking of the testimony was closed.

In compliance with this order much additional testimony was taken.

With the record in this state we come to consider the evidence introduced, but subject to the rule that the burden upon the State of New York of sustaining the allegations of its bill is much greater than that imposed upon a complainant in an ordinary suit between private parties. Before this court can be moved to exercise its extraordinary power under the Constitution to control the conduct of one State at the suit of another, the threatened invasion of rights must be of serious magnitude and it must be established by clear and convincing evidence. *Missouri* v. *Illinois*, 200 U. S. 496.

The water of New York Bay is such a brackish combination of salt sea and fresh water that it could not, under any circumstances, be used for drinking or other domestic purposes and, therefore, the reasons given in the bill to justify the injunction prayed for are restricted, as we have seen, to the claims that the addition of the Passaic Valley sewage to the already polluted waters of the Bay would result, in odors offensive and unwholesome to persons bathing in them or passing over them in large vessels or in small boats or living and working upon the adjacent shores, in causing unsightly deposits on the surface of the water and chemical action injurious to the wood and metal of vessels navigating the Bay, and in rendering fish and oysters taken from such waters unfit for consumption.

The evidence introduced, as to increase of damaging chemical action upon the hulls of vessels by the proposed addition of sewage, and as to danger from air-borne diseases to persons using the water in boats and vessels or working or dwelling upon the shore of the Bay, is much too meager and indefinite to be seriously considered as

ground for an injunction, and when it is considered that for many years all of the sewage from the great population of New York City and its environs and from the large cities on the New Jersey shore (estimated, in 1912, at 900 millions of gallons daily) has been discharged into the harbor, quite untreated, the evidence does not justify the conclusion that persons bathing in or that fish or oysters subsisting in such waters can sustain much further damage from the addition to them of the sewage of the Passaic Valley, after it has been treated in the manner proposed in the stipulation with the Government.

There remains to be considered, therefore, only the offensive odors, and unsightly deposits on the surface which it is claimed will be caused by the addition of putrescible matter to the water, and it is to this claim that a large part of the evidence introduced by the complainant is directed. Much evidence was introduced tending to prove that sewage collected from so great an area as that of the Passaic Valley Sewerage District would be stale, if not septic, when it reached the treatment plant at Newark Bay and that it would, therefore, hold in solution much organic matter which would not be removed by the screening and sedimentation processes proposed, with the result that it would cause disagreeable deposits on the surface of the water—"oily and sleek fields"—and offensive odors near the place of discharge and upon the wharves and shores adjacent to the Bay.

On the other hand witnesses of seemingly equal candor and learning, and with large practical experience, called by the defendants, testified that they were confidently of the opinion that the treatment of the sewage provided for in the stipulation with the United States would cause such purification of it that the results guaranteed therein would be fully realized.

It is much to be regretted that any forecast as to what the effect would be of the treatment and deeply sub-

merged discharge through multiple outlets proposed for this large volume of sewage must depend almost entirely upon the conflicting opinions of expert witnesses, for experience with such treatment and dispersion under even approximately like conditions seems entirely wanting. It is, however, of much significance that the authorities of the City of New York, after many years of investigation of the subject of sewage disposal, in their latest plans propose to adopt a treatment of screening and sedimentation and dispersal in deep water very similar to, but not so extensive and thorough as, that provided for in the stipulation between the defendants and the United States.

There is only one point upon which all the experts called for the opposing parties agree, viz.: that in the present state of learning upon the subject the amount of dissolved oxygen in water is the best index or measure of the degree to which it is polluted by organic substances, it seemingly being accepted by them all that upon the oxygen content in water depends its capacity for digesting sewage—that is for converting organic matter into inorganic and harmless substances by direct oxidation and by sustaining bacteria which assist in such conversion.

The witnesses agree that so long as there is sufficient dissolved oxygen in the water the process of digestion of the sewage will go forward without producing offensive odors and that when it sinks below a required percentage of saturation such odors will appear, but, unfortunately, there is a wide divergence of opinion among them as to what the required lower percentage is. The opinions of seemingly well qualified experts vary in giving from 25% to 50% of saturation as the amount of oxygen necessary to prevent the appearance of such offensive odors from decomposition of organic matter.

Measured by this dissolved oxygen standard, the evidence of the complainant is that as early as 1906 the

water adjacent to New York City, especially in the Bronx and lower East River, was much polluted by sewage, but that the water in other parts of the Bay, especially near Robbins Reef Light was somewhat, but not greatly, contaminated. This condition, the evidence shows, continued with no very pronounced decrease in the oxygen content of the water until 1911 when the investigations embodied in the first testimony taken were concluded. And the evidence taken under the order of the court in 1919 shows an irreconcilable conflict in the testimony as to the then condition of the water, especially near Robbins Reef Light, and as to the probable condition of it to be anticipated in the future. In the interval from 1906 to 1919 the estimated growth of the population of New York City and its suburbs draining sewage into adjacent waters was in excess of 100,000 a year—an increase of population in the aggregate much greater than the total population of the Passaic Valley Sewerage District at present, and approximately equal to its estimated population in 1940—and it is undisputed that this New York sewage, untreated, was discharged from over 450 sewers directly into the adjacent waters, for the most part at or above the line of low tide, and that only in a few instances was it carried even to the pier heads.

It would seem, therefore, that, if the anticipations of the experts for the complainants, as to the results likely to be produced by the effluent from the sewer of defendants, were well founded, by the year 1919 conditions in the harbor should have become so pronounced and plain that there could not have been such conflict as the record shows in the testimony of trustworthy and competent scientists as to its then existing condition.

Considering all of this evidence, and much more which we cannot detail, we must conclude that the complainants have failed to show by the convincing evidence which the law requires that the sewage which the defendants intend

to discharge into Upper New York Bay, even if treated only in the manner specifically described in the stipulation with the United States Government, would so corrupt the water of the Bay as to create a public nuisance by causing offensive odors or unsightly deposits on the surface or that it would seriously add to the pollution of it.

The evidence taken in 1919 also discloses that other means than those specifically described in the Government stipulation may be resorted to, if needed, for the purpose of improving the character of the effluent from the sewer, viz.: slower and more prolonged sedimentation processes; additional screening; the aëration of the sewage before it reaches the treatment plant and again after treatment and before discharge into the tunnel conveying it to the Bay; and finally, if required, chemical treatment.

Having regard to the treatment of the sewage prescribed in what we regard as a valid contract on the part of the defendants with the Government of the United States, to the specific agreement therein for protection of the waters of Upper New York Bay from pollution, and to the means which the Government will have to secure further purification, if desired, by refusing to permit the discharge of sewage into the Bay to continue, we conclude that the prayer for injunction against the operation of the sewer must be denied.

We cannot withhold the suggestion, inspired by the consideration of this case, that the grave problem of sewage disposal presented by the large and growing populations living on the shores of New York Bay is one more likely to be wisely solved by coöperative study and by conference and mutual concession on the part of representatives of the States so vitally interested in it than by proceedings in any court however constituted.

The court, recognizing the importance of the ruling which it is making to the great populations interested,

as well in the State of New Jersey as in the State of New York, will direct that the decree denying the relief prayed for shall be without prejudice to the instituting of another suit for injunction if the proposed sewer in operation shall prove sufficiently injurious to the waters of the Bay to lead the State of New York to conclude that the protection of the health, welfare or commerce of its people requires another application to this court.

It results that the bill of complainant will be dismissed but without prejudice to a renewal of the application for injunction if the operation of the sewer of defendants shall result in conditions which the State of New York may be advised requires the interposition of this court.

Bill dismissed without prejudice.